The Next Wave: Urgently Needed New Steps to Control Warheads and Fissile Material

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This report expands on a chapter originally written for a forthcoming study on the non-proliferation regime, *Repairing the Regime*, edited by Joseph Cirincione and published by Routledge and the Carnegie Endowment for International Peace.

FOREWORD

The risk of nuclear proliferation increased dramatically with the collapse of the Soviet Union and the end of the cold war. The long standing strategy of denying would-be proliferants access to nuclear materials was put at grave risk when the Soviet system disintegrated and Russia's nuclear security infrastructure was undercut. As the threat of deliberate superpower nuclear exchanges became a thing of the past, the danger that small states or terrorist groups might exploit the lack of effective nuclear safeguards over material and personnel in the former Soviet Union to acquire nuclear weapons became a menacing reality.

The United States government, while finally recognizing the scope of the overall risks posed by the current situation, was slow to understand the large-scale and long-term effort that would be needed to address these complex and serious threats. Few have worked as tirelessly or doggedly as Matthew Bunn in assessing these threats and in helping governments develop realistic and practical steps to deal with them. From the security of nuclear weapons and materials, to ending the production of weapons-usable materials, to disposing of excess plutonium and highly enriched uranium, to helping to develop plans for the commercial employment of Russian nuclear scientists, Matthew Bunn has enriched the understanding of these issues and contributed materially to their solution. In calling attention to the still urgent need to do more, he is again providing a valuable service.

The Carnegie Endowment's Non-Proliferation Project and Harvard's Belfer Center for Science and International Affairs are pleased to join in producing this valuable assessment of how far US-Russian cooperative efforts to address nuclear security have progressed and how far we have yet to go. Both programs are dedicated to improving the public's understanding of these issues, and to producing constructive and practical research to help policy makers address the national security threat now facing the United States as a result of nuclear insecurity in the former Soviet Union.

Jessica Mathews
President
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EXECUTIVE SUMMARY

Nothing could be more central to U.S. and world security than ensuring that nuclear warheads and their essential ingredients—plutonium and highly enriched uranium (HEU)—do not fall into the hands of terrorists or proliferating states. If plutonium and HEU become regularly available on a nuclear black market, nothing else we do to prevent the proliferation of nuclear weapons will succeed. Similarly, unless stockpiles of nuclear warheads and fissile materials can be secured, monitored, and verifiably reduced, it will be impossible to achieve deep, transparent, and irreversible reductions in nuclear arms. Measures to control warheads and fissile materials, therefore, are central to the entire global effort to reduce nuclear arms and stem their spread. The tens of thousands of nuclear weapons and hundreds of metric tonnes of plutonium and HEU that remain in the U.S. and Russian nuclear stockpiles represent a deadly legacy of the Cold War, and managing them securely must be a top U.S. security policy priority.

Urgent Security Threats

Today, there remains a clear and present danger that insecure nuclear materials could be stolen and fall into hostile hands. This danger is particularly acute in the former Soviet Union, where a security system designed for a single state with a closed society, closed borders, and well-paid, well-cared-for nuclear workers has been splintered among multiple states with open societies, open borders, desperate, underpaid nuclear workers, and rampant theft and corruption—a situation the system was never designed to address. As a result, there have been multiple confirmed cases of theft of real weapons-usable nuclear materials. As recently as 1998, a group of conspirators at a major Russian nuclear weapons facility attempted to steal enough material for a nuclear bomb at a single stroke. While there is no evidence that enough material for a bomb has yet fallen into the hands of states such as Iran, Iraq, or North Korea, such a proliferation disaster could occur at any moment. At the same time, virtually none of the measures that would be required to verifiably reduce stockpiles of nuclear warheads and materials to low, agreed levels are in place—and those measures will have to be developed by the states with the largest stockpiles, the United States and Russia.

Current Programs to Address the Threats

Since the demise of the Soviet Union, the United States has undertaken dozens of programs costing hundreds of millions of dollars a year to cooperate with the former Soviet states to address these threats. Other nations have also contributed, on a far more limited scale. If judged against the almost total lack of nuclear security cooperation as recently as early 1994, the progress of these efforts is nothing short of dramatic. Thousands of nuclear weapons have been dismantled, tens of tonnes of nuclear material has been equipped with modern security and accounting equipment, and tens of tonnes more—enough for thousands of nuclear weapons—has been blended into forms that can never again be used in weapons. The many people who have worked incredibly hard under difficult conditions to move these efforts forward have made remarkable contributions to U.S. and world security. These programs—representing less than one quarter of one percent of the defense budget—are among the most cost-effective investments in U.S. security found anywhere in the U.S. budget, and deserve strong support.

But if judged against the scale and urgency of the threat, or the opportunities available to address it, current efforts still fall woefully short. After some six years of effort, less than one-sixth of the Russian plutonium and HEU is in facilities fully equipped with modern security and accounting systems. Russia's nuclear weapons complex remains dangerously oversized and underfunded. Seven years after the initial agreement to purchase blended HEU from dismantled Russian warheads, less than one-tenth of the HEU in Russia (and still less of the U.S. HEU stockpile) has been blended to forms that can never again be used in weapons.

This pace of progress simply does not match the scope and urgency of the threat—or the opportunities available to address it. There are many factors that constrain the pace at which these urgent security threats can be reduced. But the time has come to provide the resources needed to ensure that lack of funding and leadership from the U.S. side are no longer among the key constraints. The Clinton Administration has announced that its policy for national missile defense is to ensure that the program is "limited only by what is technologically practical, not by money": the same approach should be taken for the far less costly task of controlling proliferation at its source.

Unfortunately, though announced with great fanfare as a two-thirds increase in funding for programs to "safeguard nuclear materials and technology," President Clinton's Expanded Threat Reduction Initiative keeps funding for most of these programs essentially flat, and included no new initiatives to jump-start the effort to reduce the security hazards posed by these deadly Cold War nuclear stockpiles. By contrast, in its budget proposal for fiscal year 2001, the Administration has proposed a $100 million package that finally calls for real increases for programs to reduce the urgent security threats posed by weapons-usable nuclear materials in the former Soviet Union, including new initiatives to accomplish that objective. That initiative deserves strong support—but it is still only a fraction of what would be required to address these security threats as rapidly and effectively as possible.

The "Next Wave": a Comprehensive New Nuclear Security Plan

This report outlines a comprehensive strategy for faster and more effective programs to secure, monitor, and reduce these dangerous nuclear stockpiles in the former Soviet Union and the United States, including dozens of specific proposals. The basic principle of this strategy is to provide the resources necessary to reduce the security hazards posed by these dangerous stockpiles as rapidly as technology and cooperation with the former Soviet states will allow, giving this effort priority commensurate with the threat to U.S. security.

The strategy can be summarized as a six-point plan requiring the expenditure of $1-$1.5 billion a year for each of the next five years—roughly a doubling or tripling of currently planned funding for programs related to safeguarding warheads and fissile material. The six key elements of the plan are listed in the table below, and then fleshed out in somewhat more detail.

Two fundamental points about these programs need to be made from the outset. First, these efforts can only succeed as genuine partnerships with the former Soviet states, serving their interests as they serve U.S. interests, and with former Soviet experts playing leading roles in their design and implementation. Second, these programs are not about providing large checks to go into bank accounts of dubious ownership, in the hope that some good will result: they are about paying for specific, demonstrable goods and services—warheads dismantled, security systems installed, bomb uranium blended down. As such, they are not charity, but investments in the security of the United States, and of the international community as a whole.

An Agenda for Action: Summary of Key Proposals

Proposal	***Approximate Cost Over Five Years (est.)***
Expand nuclear material security and accounting program to a level not constrained by funding	$1.3 billion
Pay costs and financial incentives to blend all excess HEU to LEU within a few years	$1 billion
Finance disposition of excess Russian plutonium	$2 billion
Help shrink Russian nuclear weapons complex, and re-employ excess scientists and technicians	$0.5 billion
Offer to finance transparent dismantlement of thousands of warheads, with reciprocity	$0.5 billion
Expand available revenue for nuclear security through spent fuel storage, HEU purchases, debt swaps, and/or lifting restraints on legitimate exports	$0-$2 billion
Total:	$5-$8 billion

A NUCLEAR MATERIAL SECURITY AND ACCOUNTING PROGRAM NOT CONSTRAINED BY FUNDING. The programs intended to ensure that all nuclear weapons and weapons-usable nuclear material are secure and accounted for should be drastically expanded and accelerated, providing the resources to accomplish that job as fast as it can be done. Lack of funding should not be allowed to be among the major constraints on progress.

An expanded and accelerated program to improve security and accounting for nuclear material should focus on accomplishing three key objectives as rapidly as possible: (a) consolidating material in the smallest practicable number of buildings and sites; (b) providing both facility-level and national-level security and accounting system improvements as quickly as practicable; and (c) helping to put in place the resources, incentives, and organizations needed to sustain effective security over time (including ensuring that security and accounting upgrades are actually used and maintained). The latter goal involves changing ways of thinking and patterns of organizational behavior, which is a challenge that involves much more than money—but the plan outlined in this report includes a wide range of specific steps to help achieve those objectives. As part of the consolidation effort, there are particularly promising opportunities to address the proliferation threats posed by the smallest, most desperate facilities by simply buying the HEU from those facilities for shipment elsewhere, while providing assistance to convert those facilities to other types of research.

A funding level of $250 million per year for perhaps five years represents a *minimum* level for such a funding-unconstrained program; further creative thinking may identify opportunities that would require still larger levels of funding. To protect the U.S. investment, the program should be continued at a modest level—perhaps $50 million per year—for a considerable period after the initial upgrades are accomplished, to ensure that security and accounting systems are sustained and improved, and to maintain cooperation and communication concerning the state of nuclear security.

PAYING FOR RAPID BLEND-DOWN OF EXCESS RUSSIAN HEU. The Russian facilities that are blending HEU from dismantled Russian weapons to forms that can never again be used in weapons, for sale to the United States as commercial reactor fuel, would need only a few additional machines—costing only about $1 million—to double the current 30-tonnes-per-year pace of blending. That would mean destroying enough material for thousands of additional bombs each year. (The current pace was determined by what the commercial market would bear, not by what the national security demanded.) No one yet knows how much blending capacity could be provided for investments of $10 million, $50 million, or $100 million. The United States should aggressively pursue a new initiative to pay the costs of blending all of Russia's excess HEU—including stocks above and beyond the 500 tonnes Russia has declared excess already—to non-weapons-usable forms within a few years, and provide substantial financial incentives to Russia to undertake such a rapid blending effort. The blended material would continue to be released on the market at a pace consistent with commitments made to uranium industry firms as part of the existing HEU purchase agreement. The total cost is uncertain, as no one yet knows how large a financial package would be needed to gain Russian agreement, but might be in the range of $1 billion over several years. That would be a small price to pay for permanently eliminating the security hazards posed by Russia's massive excess stockpiles of HEU. Some of the funding could be in the form of prepayments against future deliveries of the blended material, allowing a portion of the funds to be recouped when the material is delivered for commercial sale.

FINANCING DISPOSITION OF RUSSIAN EXCESS PLUTONIUM. Reducing excess plutonium stockpiles as rapidly as practicable is also a high priority. Russia does not have the money to accomplish this objective. Paying the $1-$3 billion needed to finance the transformation of Russia's weapons plutonium into forms that are no longer suitable for use in nuclear weapons—effectively eliminating the material for many thousands of nuclear weapons—would be a highly cost-effective investment in U.S. national security. If a plan can be worked out that would make it possible to carry out disposition of this excess plutonium stockpile on a reasonable timetable, it would make sense to fund this investment, over a period of perhaps 5 years. The first priority should be to ensure that all the excess plutonium is secure, placed under monitoring, and converted to unclassified forms as rapidly as practicable, pending longer-term disposition. (The needed steps on disposition of excess plutonium are described in more detail on pp. 67–73.)

Helping to Shrink the Russian Nuclear Complex. Russia and the United States share crucial national security interests in shrinking Russia's oversized and underfunded nuclear weapons complex to a sustainable size appropriate to its post-Cold War missions, and reemploying the thousands of scientists and technicians who are no longer needed for nuclear weapons work. From Russia's perspective, a smaller complex would be cheaper to maintain, mitigate the social instability and proliferation risks posed by the desperate funding situation that now permeates the complex, and harness the talents of those no longer needed for weapons work to crucial civilian tasks. From the U.S. perspective, a smaller complex would have a greatly reduced ability to produce thousands of nuclear weapons to be targeted on the United States, and providing sustainable employment for the excess scientists and technicians would greatly reduce the incentives for theft of nuclear material or sale of nuclear knowledge posed by the financial desperation that currently permeates the complex. A comprehensive approach to this problem would include, at a minimum: (a) assistance for closing or converting facilities for the production of nuclear weapons, nuclear weapons components, and materials for nuclear weapons; (b) a broad range of measures to support private-sector employment growth (ranging from business development centers to tax incentives for employment of excess nuclear weapons workers), including both establishment of new businesses in these cities and employment of nuclear city experts as "knowledge workers" working for outside businesses over the internet; (c) support for employment of nuclear city experts on nonproliferation and arms control analysis and technology development (providing employment well-matched to their nuclear skills while serving other U.S. arms control and proliferation interests as well); and (d) support for employment of nuclear city experts on tasks related to nuclear cleanup, energy, and the environment. The third and fourth of these areas could be supported in a "win-win" approach by contracting a fraction of the hundreds of millions of dollars the Department of Energy spends each year on R&D in these areas to experts from the nuclear cities—getting the Department's work done for less while providing interesting and relevant R&D employment to excess experts in the nuclear cities.

Assistance for Transparent Dismantlement of Thousands of Warheads. Increased transparency in the management of nuclear warhead and fissile material stockpiles (while maintaining protection for legitimate nuclear secrets) will be fundamental to achieving deep reductions in nuclear arms, as well as cooperation to secure nuclear stockpiles—and hence to reducing the nuclear threat to the United States. Unfortunately, Russian secrecy concerns have largely blocked transparency progress in recent years, and increased concern over protecting nuclear secrets in the United States in the wake of the Chinese espionage scandal is likely to make increased transparency a hard sell in the United States as well. To date, the United States has not offered Russia any significant incentives—strategic, financial, or otherwise—to agree to accept wide-ranging transparency for warhead and fissile material stockpiles.

To jump-start the stalled process of formal negotiations over warhead limitations and transparency, President Clinton should propose a new initiative, modeled on the successful informal reciprocal-unilateral initiatives launched by President Bush and Soviet President Gorbachev in 1991, which resulted in the pull-back and dismantlement of many thousands of nuclear weapons. For example, President Clinton could offer to place a large fraction of the U.S. strategic reserve and tactical nuclear warheads (stockpiles unregulated by arms control to date, and which will represent the vast majority of the total U.S. warhead stockpile under START II) in secure storage open to Russian monitoring, and commit them to verifiable dismantlement (with specific procedures to be worked out later), if Russia would do the same with its comparable warhead stockpiles. This could address Russian concerns about the U.S. maintenance of a large stockpile of reserve strategic warheads that could be rapidly returned to missiles, and U.S. concerns about the huge Russian tactical warhead stockpile. Within a few months, the majority of all the warheads in both sides' nuclear arsenals could be under reciprocal monitoring, and committed to dismantlement. Indeed, technology exists that would make it possible to permanently and verifiably disable these warheads, pending their eventual dismantlement, rather than only subjecting them to monitoring.

As part of this package, the United States should offer to provide financial assistance for warhead dismantlement in return for Russian agreement to a transparency package that would also be implemented reciprocally at the Pantex dismantlement facility in the United States. The transparency measures would have to be designed jointly by U.S. and Russian experts, to give both sides confidence that they could confirm dismantlement was taking place without revealing sensitive information. Preliminary U.S.-Russian lab-to-lab work in designing such measures is already under way. The total cost of such an effort, including the financial assistance for warhead dismantlement, might be in the range of half a billion dollars over several years.

EXPANDING AVAILABLE REVENUE FOR NUCLEAR SECURITY. The cost of many of the nonproliferation and arms reduction tasks that are urgently needed is substantial, and the former Soviet states are facing desperate budget problems. At the same time, there is increasing "donor fatigue" among the states providing assistance, and there is a wide range of critical steps that are difficult or impossible for foreign governments to fund—such as paying the salaries of nuclear guards. Hence, finding new sources of revenue for nuclear security is critically important. Promising concepts include commercial spent fuel storage in Russia, with a substantial portion of the revenues going to nuclear security and cleanup; additional purchases of HEU, premised on a portion of the proceeds being directed to nuclear security efforts; a "debt-for-security" swap, in which a portion of Russia's foreign debt would be canceled in return for Russia paying smaller amounts into an auditable fund to finance nuclear security; and modifications to the stringent trade restraints limiting Russia's access to markets for civilian nuclear exports, premised on

Russian agreement to devote an agreed portion of the proceeds of expanded exports to nuclear security. Such initiatives could provide billions of dollars in much-needed revenue to address the security hazards posed by the dangerous Cold War legacy of nuclear warheads and materials.

The Need for Leadership

Unfortunately, there is no single "silver bullet" that will address the myriad risks to international security posed by the gigantic nuclear stockpiles and complex of the former Soviet Union. A broad "next wave" of new measures to reduce these risks is needed, representing roughly a doubling or tripling of current funding for programs devoted to reducing these security threats. Such an expanded effort can only succeed in close cooperation with the states of the former Soviet Union, who will have to play a central role in its design from the very outset. While important progress is already being made in nuclear security cooperation with these states, at the current pace there can be no confidence that a proliferation catastrophe will be averted, or the foundation laid for transparent and irreversible nuclear arms reductions.

To reinvigorate these efforts with new initiatives, to make them work as a package, to coordinate, prioritize, and integrate them into a strategic plan, and to negotiate them with Russia and the other former Soviet states, will require a dramatic increase in sustained leadership from the highest levels of the U.S. government. Too often in recent years, President Clinton has said a few words about the high priority of these issues, and then has failed to follow through with the sustained commitments of money, personnel, and political attention needed to get the job done. President Clinton, Vice President Gore, and their White House staff have allowed myriad other events to distract attention from the fundamentally important task of ensuring that the essential ingredients of nuclear weapons do not fall into the wrong hands.

There is still time to correct this situation—and if President Clinton fails to do so, the next President must act. In addition to a sea change in sustained Presidential leadership on these issues, two fundamental steps are necessary: the appointment of a senior official with direct access to the President, with full-time responsibility to carry out these efforts, and the development of a strategic plan setting priorities, targets, and timetables, and identifying the key synergies among the many efforts being pursued. The current organizational structure of the government, with programs scattered through many departments and no one in charge of coordinating and leading them on a full-time basis, is simply not suited to the task of managing this broad range of crucial nonproliferation and arms reduction efforts. A senior, full-time point person for these efforts is needed, with direct access to the President and appropriate staff and resources—on the model of former Secretary of Defense William Perry's return to government to reshape the U.S. approach to the North Korean nuclear and missile threat, or even on the model of Gen. Barry McCaffrey's White House office leading U.S. anti-drug efforts. Preventing nuclear material from falling into the hands of states like North Korea or Iraq is certainly no less critical to U.S. security than drugs or the North Korean nuclear program itself.

There is much to be done to address the security risks posed by the deadly Cold War legacies of plutonium and highly enriched uranium. The cost of taking action now to address this threat is tiny by comparison to the cost and risk of failing to act and finding that the essential ingredients of nuclear weapons find their way into the hands of terrorists or proliferant states. The time for action is now. Indeed, we cannot afford to wait.

I. INTRODUCTION

Nothing could be more central to U.S. and world security than ensuring that nuclear warheads and their essential ingredients—plutonium and highly enriched uranium (HEU)[1]—do not fall into the hands of terrorists or proliferating states. If plutonium and HEU become widely available on a nuclear black market, nothing else we do to prevent the proliferation of nuclear weapons will succeed. Similarly, unless stockpiles of nuclear warheads and fissile materials can be secured, monitored, and verifiably reduced, it will be impossible to achieve deep, transparent, and irreversible reductions in nuclear arms. Measures to control warheads and fissile materials, therefore, are central to the global effort to reduce nuclear arms and stem their spread.[2]

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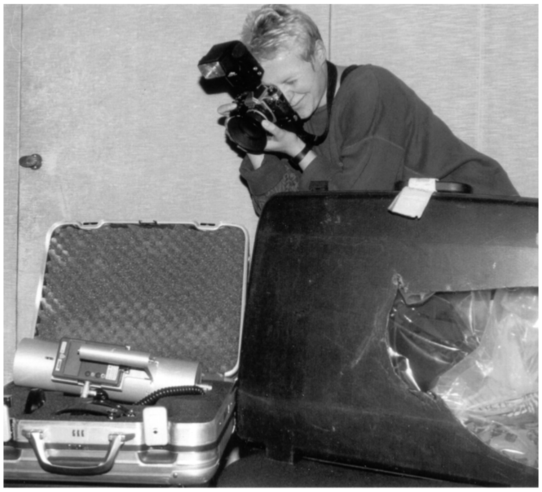
[1] All nuclear explosives require some form of fissionable material capable of supporting an explosive chain reaction. As far as is known, the material used in all the weapons in existence today is plutonium, HEU, or some combination of the two. Some "alternative nuclear materials," however, such as certain isotopes of neptunium and americium (among others) could also be used as the basis for nuclear explosives.

[2] For a discussion of the technical background of this issue, and a detailed review of the status of programs to address it as of mid-1997, see Matthew Bunn and John Holdren, "Managing Military Uranium and Plutonium in the United States and the Former Soviet Union," *Annual Review of Energy and the Environment*, 1997, Volume 22, pp. 403-486 (available at http://ksgnotes1.harvard.edu/BCSIA /Library.nsf/atom). For previous attempts at comprehensive sets of recommendations on fissile material control, see, for example, Sam Nunn (chair), *Managing the Global Nuclear Materials Threat – Policy Recommendations*, Washington, DC: Center for Strategic and International Studies, January, 2000 (drafted in part by the present author); John P. Holdren and Matthew Bunn, "Reducing the Risk of Nuclear Theft," in Joseph Rotblat, ed., *Nuclear Weapons: The Road to Zero*, Boulder, CO: Westview Press, 1998 (available at http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/atom); Graham T. Allison, Owen R. Coté, Jr., Richard A. Falkenrath, and Steven E. Miller, *Avoiding Nuclear Anarchy: Containing the Threat of Loose Russian Nuclear Weapons and Fissile Material*, Cambridge, MA: MIT Press, CSIA Studies in International Security, 1996; and David Albright and Kevin O'Neill, eds., *The Challenges of Fissile Material Control*, Washington DC: Institute for Science and International Security, March 1999. For recent sets of recommendations focused on specific areas, see National Research Council, Committee on Upgrading Russian Capabilities to Secure Plutonium and Highly Enriched Uranium, *Protecting Nuclear Material In Russia*, Washington DC: National Academy Press, 1999; Congressional Budget Office, *Cooperative Approaches to Halt Russian Nuclear Proliferation and Improve the Openness of Nuclear Disarmament,* Washington DC: Congressional Budget Office, May 1999; and the papers evaluating cooperative threat reduction programs prepared by teams from the Center for Nonproliferation Studies of the Monterey Institute of International Studies, forthcoming in *Nonproliferation Review.* While the programs and recommendations outlined in this report cover a broad range of activities, they are focused specifically on security issues relating to management of nuclear warheads and nuclear material, not on the broader agenda of nonproliferation, arms control, and cooperative threat reduction in which the United States is engaged with the states of the former Soviet Union, or on environmental issues. Thus, issues ranging from export controls to START II, from de-alerting to biological disarmament, are not addressed here.



This suitcase carried plutonium seized from a flight from Moscow to Munich in 1994, as a result of a German sting operation. There have been multiple documented cases of theft of kilogram quantities of weapons-usable plutonium and highly-enriched uranium from former Soviet facilities in the 1990s, and urgent new steps are needed to prevent these deadly materials—the essential ingredients of nuclear weapons—from falling into the hands of terrorist groups or proliferating states. Source: AP

Today, however, there is a clear and present danger that insecure nuclear materials could be stolen and smuggled to potential proliferators. This is a global problem requiring global cooperation. But a significant part of the problem is in the former Soviet Union, where controls have been dramatically weakened by ongoing economic and political upheavals. At the same time, virtually none of the measures that would be required to verifiably reduce stockpiles of nuclear warheads and materials to low, agreed levels are now in place—and those measures will have to be developed by the states with the largest stockpiles, the United States and Russia.

Since the demise of the Soviet Union, the United States has undertaken dozens of programs costing hundreds of millions of dollars a year to cooperate with the former Soviet states to address the security threats by the vast stockpiles of warheads and fissile material left over from decades of Cold War. Other nations have also contributed, on a far more limited scale. If judged against the almost total lack of nuclear security cooperation as recently as early 1994, the progress of these efforts is nothing short of dramatic. The many people who have worked incredibly hard under difficult conditions to move these efforts forward have made remarkable contributions to U.S. and world security.

But if judged against the scale and urgency of the threat, or the opportunities available to address it, current efforts still fall woefully short. A "next wave" of targeted cooperative efforts to improve the management of nuclear weapons and weapons-usable nuclear materials is urgently needed, to rapidly reduce the risks of proliferation and provide a firm basis for deep reductions in nuclear arms. The Clinton Administration has announced that its policy for national missile defense is to ensure that the program is "limited only by what is technologically practical, not by money": the same approach should be taken for the far less costly task of controlling proliferation at its source.[3] Unfortunately, the Expanded Threat Reduction Initiative (ETRI) announced in early 1999 fell far short of this goal, doing little more than maintaining flat funding for existing programs related to these critical proliferation threats (see "The Expanded Threat Reduction Initiative," p. 62). While a useful step, ETRI would leave most of what is required for such a "next wave" of fissile material security programs still undone. The

[3] "National Missile Defense Policy," remarks of Undersecretary of Defense Walter Slocombe, Washington DC: Center for Strategic and International Studies, November 5, 1999. In this case, progress will be limited not only by what is technologically practical but also by what the degree of cooperation achieved with the states of the former Soviet Union will permit.

$100 million new "long-term nonproliferation program for Russia" proposed by the Clinton Administration in early 2000, while an extremely valuable step, is still a fraction of the level of effort that would be required to reduce these security hazards and quickly and effectively as possible (see "DOE's Proposed Long-Term Nonproliferation Initiative for Russia," p. 70).

Is dramatic new progress in U.S.-Russian nuclear security cooperation possible? Experience suggests that the answer is "yes". In the fall of 1998, in the last hours of negotiations over the federal budget, Senator Pete Domenici (R-NM), chairman of the Senate Budget Committee, suddenly inserted over half a billion dollars to save the U.S. purchase of 500 metric tonnes of HEU from dismantled Russian weapons, and to provide the basis for progress in negotiations over disposition of excess plutonium (both described in more detail below). After intensive further negotiations on both fronts, Domenici's initiative led directly to U.S.-Russian agreements that restarted Russian blending of HEU from dismantled weapons and started the process of eliminating tens of tonnes of excess weapons plutonium, neither of which would have been possible without Domenici's intervention. After years of interagency and executive-legislative wrangling over a few tens of millions of dollars for this program or that, Domenici's initiative served as compelling proof that energetic leadership and a commitment to provide requisite funding can break through logjams and open new possibilities.

Without doubt, there are enormous obstacles to a major expansion of U.S.-Russian nuclear security cooperation (see "Obstacles to Cooperation," p. 4). With souring U.S.-Russian political and strategic relations, the window of opportunity for far-reaching security cooperation between the United States and Russia is clearly not as open as it was in the early 1990s, and no one knows how long the remaining opportunities will last.

But even within the context of U.S.-Russian relations as they now stand, and in a Presidential election year in both the United States and Russia, there is much that could be done. The recent ascension to power of a new and energetic Russian President, apparently in firm control of the security agencies of the Russian government, gives cause for optimism that new initiatives that President Putin saw as serving Russia's security interest could gain approval and be swiftly implemented on the Russian side. Many of the needed new initiatives can and should still be undertaken in the remainder of Bill Clinton's presidential term. What is left undone at the end of that term will represent the agenda for the next president, on one of the most critical national security issues the United States now faces.

More than anything, what is needed now is a substantial and sustained increase in high-level leadership from the White House. A bipartisan panel chaired by former Senator Sam Nunn recently called for a "sea change in the level of sustained leadership from the highest levels of the U.S. government—including the President and the Vice President," arguing that "it is simply unacceptable to continue a situation in which lack of sufficient funding and senior leadership attention on the U.S. side are among the major factors preventing faster and more effective actions to reduce these serious security threats."[4] As Senator Joseph Biden (D-DE) has recently written, "The war against these

[4] *Managing the Global Nuclear Materials Threat – Policy Recommendations*, op. cit.

Obstacles to Nuclear Security Cooperation

There are enormous obstacles to genuine cooperation in sensitive nuclear security areas between former adversaries like the United States and Russia. The souring of U.S.-Russian political relations during 1998 and 1999, accelerated by NATO's bombing of Yugoslavia, has made cooperation even more difficult, and the hurdles to be overcome if major new steps are to succeed even higher. The politics of Presidential elections in both countries, Russia's increased reliance on nuclear weapons, and the sharpening dispute between the two sides over missile defenses and arms reductions further complicate the picture. The experience of the last several years makes clear that nuclear security cooperation can succeed only if it is approached as a genuine partnership, with experts from both sides contributing their work and ideas to solve common problems together—rather than as an effort by one side to impose solutions on the other.

The most fundamental obstacle to cooperation is that the United States and Russia continue to have many conflicting interests—though they have profound common interests in preventing the proliferation of nuclear weapons and achieving permanent nuclear arms reductions. Russia would like to maintain a cutting-edge nuclear arsenal comparable to that of the United States, and the United States has no interest in helping Russia do that. Both countries' intelligence services would like to find out as much as possible about the other country's nuclear secrets, and both countries are deeply suspicious of the other's intentions in that regard. The United States has an interest in achieving specific nonproliferation and arms reduction goals as quickly and cost-effectively as possible; Russia, while not opposed to that objective, also has an interest in providing as much employment for excess nuclear workers as possible for as long as possible. Substantial segments of the political establishments in both countries—including a large fraction of both countries' legislatures—remain deeply suspicious of the other, and skeptical of the whole idea of nuclear security cooperation (which creates a constant danger that problems will be blown out of proportion and spin out of control). Given these differences of interest, disagreements about specific approaches to cooperation are inevitable, and need to be resolved patiently with good-faith negotiation and discussion.

Secrecy and limited access to facilities is another serious obstacle faced by essentially all cooperative nuclear security programs with Russia. Enormous progress has been made in breaking down barriers, particularly compared to the early 1990s, when Russia would not allow cooperation on security upgrades at *any* site with separated plutonium or HEU, even civilian ones—whereas today, cooperation is underway at almost *every* such site. But enormous barriers still remain, and as political relations have deteriorated, the Russian security services have become more active in restricting access. At the same time, the United States has frequently been reluctant to offer comparable access to its own facilities, and this, too, has slowed progress. The recent furor over Chinese spying and laboratory security in the United States is only making this problem worse.

Competing priorities, bureaucratic disorganization, frequent changes of government personnel,

'loose nukes' and 'brain drain' threats is as important as any war in our history… it is a war that the United States dares not lose."[5]

Structure of the report

Section II of this report describes the threats the international community now faces that relate to management of nuclear material in the former Soviet Union, in five key categories: (a) the inadequate security of nuclear materials; (b) the continued existence of an oversized and underfunded nuclear complex; (c) the lack of international

[5] "Maintaining the Proliferation Fight in the Former Soviet Union," *Arms Control Today*, March 1999.

and lack of sustained attention to these issues by the highest levels of government have been serious problems on both sides. It is difficult to do business with a Russian government facing a thousand priorities it considers more urgent, whose prime minister changes every few months, whose ministries often do not communicate, whose nuclear facilities increasingly may not abide by deals cut in Moscow, whose officials often put their industry's commercial interests ahead of nonproliferation interests, and whose senior leadership takes only occasional interest in resolving issues related to these nuclear security cooperation programs. Russian experts have much the same complaints about dealing with the U.S. government.

Another major issue is the difficulty of ensuring that U.S. taxpayers' dollars are being spent as they should be—an issue with several parts. First, there is the widespread corruption in Russia, which makes it essential to structure assistance programs so that the funds cannot simply be raked off into foreign bank accounts. Second, Russia has a dysfunctional payments system, in which, for example, money deposited at a particular bank for use by a joint project at a nearby institute may be seized by the bank to cover the institute's bad debts, or may be seized by tax police to cover the institute's back taxes, or may be used by a desperate institute director to pay salaries of other employees (in the hopes that it can be paid back if institute's promised government funding ever comes). Third, there is the continuing problem of Russian efforts to impose a variety of taxes, tariffs, and duties on U.S. assistance, in effect directing a portion of the assistance away from the agreed projects and into the general coffers of the Russian government instead. While the specific situation of each nuclear security program is unique, all of them have faced these problems, and even when they have found successful solutions, the fact is that an enormous amount of time, energy, creativity, and political capital is spent following the money trail rather than getting the cooperative work done.

Cultural differences and poor negotiating tactics on both sides have, on occasion, also led to obstacles and disputes, which in some cases have delayed progress by months or years. What may appear from a U.S. perspective to be the minimum necessary audit and examination approach to ensure U.S.-financed equipment is used appropriately may appear from a Russian perspective as unwarranted intrusion and possibly an intelligence mission. A policy change seen on the U.S. side as tightening up lax spending practices of the past may be seen on the Russian side as abrogating the spirit of partnership by ignoring Russian suggestions for how funds should be spent.

Given this list of obstacles to cooperation—which is by no means comprehensive—success in nuclear security cooperation is never guaranteed, and the obstacles to initiating major new efforts are substantial. The fundamental ingredients of success are: initiatives that genuinely serve the security interests of both sides; sustained and energetic leadership; a genuine commitment to working in partnership; a step-by-step approach designed to build trust as progress is made; patience, persistence, and creativity in overcoming obstacles; and consistent follow-through on commitments. With those ingredients, and with a willingness to apply additional financial resources, there are opportunities for dramatic new progress to deal with the nonproliferation and arms reduction challenges both countries face, and perhaps even contribute to improving the overall political atmosphere between Russia and the United States.

transparency and monitoring of these stockpiles; (d) the continued production of additional weapons-usable material; and (e) the lack of an agreed, financed, and implementable plan for reducing the vast Cold War stockpiles of warheads, plutonium, and highly-enriched uranium to levels appropriate to the post-Cold War world, in both the United States and the former Soviet Union.

Section III then provides an overview of the current cooperative programs in place to address each of these five categories of threat, including the progress these programs have made so far, the work that remains to be done, and the plans and prospects for further work in the near term. For each of the five categories of threats to be addressed, Section III provides an assessment (inherently judgmental) of the percent of the job that is already accomplished or covered by budget plans and agreements now in place—both for the relatively limited goals many of these programs originally set themselves, and for the larger goals that would have to be achieved to resolve the international security threats posed by the remaining Cold War nuclear stockpiles.

Section IV then outlines a recommended comprehensive strategy to further reduce the risks, in each of the five threat areas. While that strategy involves dozens of individual actions, the key elements can be summarized as a six-point plan requiring the expenditure of $1-$1.5 billion a year over five years—roughly a doubling or tripling of current spending on programs related to safeguarding nuclear warheads and materials. This strategy is intended to achieve a set of ambitious strategic objectives, including ensuring, within approximately five years, that (a) effective security and accounting systems have been provided for all weapons-usable nuclear material in the former Soviet Union, with a structure of resources, incentives, and organizations to ensure that security is maintained over the long haul; (b) all U.S. and Russian excess HEU has been blended to forms that can no longer be used in weapons, and large-scale disposition of excess plutonium has begun; (c) the Russian nuclear weapons complex's capacity to build many thousands of new nuclear weapons has been substantially reduced, and thousands of the scientists and technicians no longer needed for weapons work have been re-employed; and (d) agreements have been reached to reduce U.S. and Russian total warhead and fissile material stockpiles, with a broad system of transparency and monitoring to help confirm those commitments and lay the basis for deep, transparent, and irreversible nuclear arms reductions.

Finally, Section V offers some summary conclusions, focusing primarily on approaches to the leadership, management, and strategic planning that will be required to accomplish this ambitious agenda.

This report represents an American viewpoint. But unlike many of the military threats of the Cold War era, these are security threats that can only be addressed through cooperation. And the experience of nuclear security cooperation with Russia to date makes clear that these programs will only succeed if they are carried out as true partnerships, serving both Russian and American interests, with Russia playing a major part in their design and implementation. Russia is likely to remain a major nuclear power, and require a substantial nuclear complex, for as long as the United States does so, and is not likely to agree to cooperation that does not serve Russia's national interests. Moreover, while this report focuses on the situation in the former Soviet Union, the fact is that there is much to be done in improving nuclear security and transparency in many countries around the world—including in the United States.[6] Even programs focused

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[6] For discussions of the need for more international cooperation and stronger international standards to secure nuclear material worldwide, see Matthew Bunn, "Security for Weapons-Usable Nuclear Materials: Expanding International Cooperation, Strengthening International Standards," in *Comparative Analysis of Approaches to Protection of Fissile Materials: Proceedings of a Workshop at Stanford California, July 28-30, 1997,* Livermore, CA: Lawrence Livermore National Laboratory, Document Conf.-9707121, May 1998; Matthew Bunn, "Ensuring Security for Weapons-Usable Nuclear Material Worldwide: Expanding International Cooperation, Strengthening Global Standards," in *Proceedings of Global '99: Nuclear Technology- Bridging the Millennia*, Jackson Hole, Wyoming, 30 August - 2 September 1999, La Grange Park, IL: American Nuclear Society, 1999 (both available at http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/atom), and George Bunn, "Physical Protection of Nuclear Materials: Strengthening Global Norms," *IAEA Bulletin*, 39/4/1997. The first of these also provides some discussion of some of the problems that have arisen in the United States' system for security and control over nuclear materials.

primarily on the former Soviet Union will generally work best as true partnerships, involving a considerable degree of reciprocity, with similar measures implemented at facilities in the United States as well. A report like this one, therefore, offering only an American perspective and focusing primarily on what needs to be done in the former Soviet Union, can only be a starting point.

II. THE THREAT

Insecurity

Nuclear Materials

The possibility that nuclear weapons or their essential ingredients will be stolen and made available on a nuclear black market poses an urgent threat to U.S. and international security. The facts are stark:[1]

- Limited access to plutonium and HEU is the primary technical barrier to the spread of nuclear weapons. Most countries, and even some terrorist groups, could build at least a crude nuclear bomb, capable of obliterating the downtown area of a major city, if they had these materials in hand. The ability to buy these materials on a nuclear black market could shorten a proliferating state's bomb program from a decade to months—or even less. Hence, as a committee of the U.S. National Academy of Sciences recommended in 1994, plutonium and HEU should be secured and accounted for essentially as rigorously as nuclear weapons themselves are—the so-called "stored weapons standard" of protection.[2]
- The amounts required are small. Four kilograms of plutonium—an amount smaller than a soda can—or about three times that amount of HEU is potentially enough for a nuclear bomb.[3] Unless proper security and accounting systems are in place, a worker at a nuclear facility could simply put enough material for a bomb in a briefcase or

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[1] This summary of the basic facts of the problem is based largely on John P. Holdren, testimony as chairman of the Panel on U.S.-FSU Cooperation to Protect, Control, and Account for Weapons-Usable Nuclear Materials, President's Committee of Advisers on Science and Technology, before a joint hearing of the Subcommittee on Europe, Senate Foreign Relations Committee, and the Permanent Subcommittee on Investigations, Senate Committee on Governmental Affairs, August 23, 1995. The author served as the Executive Secretary of that panel, whose full report remains secret.

[2] Committee on International Security and Arms Control, National Academy of Sciences, *Management and Disposition of Excess Weapons Plutonium*, Washington DC: National Academy Press, 1994. See also George Bunn, "U.S. Standards for Protecting Weapons-Usable Fissile Material Compared to International Standards," *Nonproliferation Review*, Fall 1998, vol. 6, no. 1, pp. 137−143.

[3] These are the amounts required for a reasonably well-designed implosion bomb. A simpler gun-type weapon, which can be made with HEU but not with plutonium, requires considerably more material, in the range of 50-70 kilograms. For an interesting discussion, based on unclassified sources, arguing that with good designs and high-speed explosives, nuclear weapons can be made with as little as one kilogram of plutonium, see Thomas B. Cochran and Christopher E. Paine, *The Amount of Plutonium and Highly-Enriched Uranium Needed for Pure Fission Weapons*, Washington DC: Natural Resources Defense Council, August 22, 1994.

under an overcoat and walk out. Yet these materials exist in both the civilian and military sectors around the world in amounts measured in the hundreds of tonnes—enough for tens of thousands of nuclear weapons.

- There have already been multiple seizures, by authorities in Russia and elsewhere, of kilogram quantities of stolen weapons-usable uranium, and one seizure of hundreds of grams of weapons-usable plutonium (see details below).

That a large fraction of reports of nuclear smuggling have been scams, involving materials with no relevance to nuclear weapons, should not distract attention from the seriousness of the cases of theft of genuinely weapons-usable material that have occurred. While there is no evidence that enough material for a bomb has yet fallen into the hands of terrorist groups or states such as Iran, Iraq, Libya, or North Korea, we do not know what we have not detected. Such a proliferation disaster could occur at any time—and there is strong evidence that both hostile states and terrorist groups are seeking to acquire such material (see "The Demand for Black Market Fissile Material," p. 14).

In short, the dangers of unpredictable nuclear proliferation posed by the threat of nuclear theft are extremely grave. If a state such as Iran or Libya were to suddenly acquire the essential ingredients of nuclear weapons, the international community could be faced with a devastating new threat with virtually no warning, and hence no opportunity for diplomatic, economic, and military measures to head off the threat before it arose. The consequences to U.S. and world security would be severe, and the possible defense responses would be both extremely expensive and of uncertain effectiveness.

SOVIET SECURITY, MODERN THREATS. While the risk of nuclear theft is a global problem requiring global solutions, a critical part of the problem lies within the former Soviet Union—as evidenced by the geographic pattern of seizures to date, including those that have been made within Russia. The Soviet Union had a highly effective and intelligently designed security system for its nuclear weapons and nuclear materials—but it was designed for a world that no longer exists, and funding to maintain it has not been available. A security system designed for a single state with a closed society, closed borders, and well-paid, well-cared-for nuclear workers has been splintered among multiple states with open societies, open borders, desperate, underpaid nuclear workers, and rampant theft and corruption—a situation the system was never designed to address.[4] Even Russian Minister of Atomic Energy Evgeniy Adamov has acknowledged that "the weakening of our ability to manage nuclear material has been immeasurable."[5]

The former Soviet states are thought to possess roughly 1,350 tonnes of weapons-usable nuclear material—plutonium and HEU—of which some 700 tonnes is in nuclear weapons, and 650 tonnes is in a variety of other forms, ranging from metal weapons

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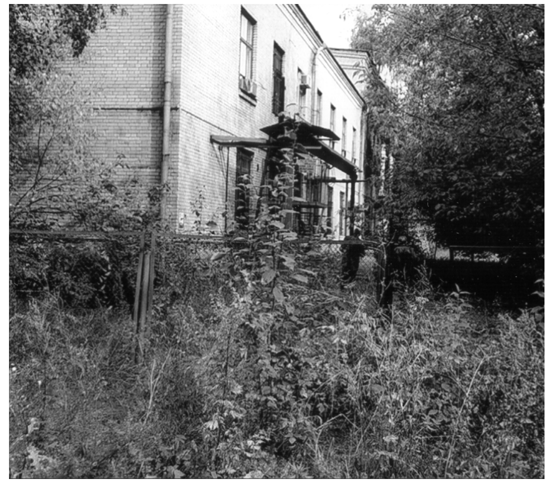
[4] For discussions, see, for example, Bunn and Holdren, "Managing Military Uranium and Plutonium," op. cit.; Oleg Bukharin, "Security of Fissile Materials In Russia," *Annual Review of Energy and the Environment*, 1996, Vol. 21, pp. 467–96; Frank von Hippel, "Fissile Material Security in the Post-Cold War World," *Physics Today*, June 1995; Allison et. al., *Avoiding Nuclear Anarchy*, op. cit; Oleg Bukharin and William Potter, "Potatoes Were Guarded Better," *Bulletin of the Atomic Scientists,* May/June 1995, pp. 46–50; Jessica Eve Stern, "U.S. Assistance Programs for Improving MPC&A in the Former Soviet Union," *Nonproliferation Review*, 1996, Vol. 4, No. 2, pp.17–32; and "We Cannot Preclude the Possibility of Nuclear Materials Theft," (edited transcript of Duma hearing), *Yaderny Kontrol Digest* No. 5, Fall 1997.

[5] Nick Wadhams, "Center to Track Russian Nuclear Material," *Associated Press*, November 4, 1998.

components to impure scrap.[6] These materials are stored in over 50 sites, at which there are estimated to be nearly 400 buildings containing at least kilogram quantities of plutonium or HEU. All of the nuclear weapons in the former Soviet Union are in Russia, as is some 99% of the weapons-usable material, but civilian facilities in Belarus, Kazakhstan, Latvia, Ukraine, and Uzbekistan also have quantities large enough to pose proliferation risks. Serious security problems and risks of theft exist throughout this huge complex of facilities. Indeed, in 1996, the U.S. Director of Central Intelligence testified that weapons-usable nuclear materials "are more accessible now than at any other time in history—due primarily to the dissolution of the former Soviet Union and the region's worsening economic conditions," and that *none* of the facilities handling plutonium or HEU in the former Soviet states had "adequate safeguards or security measures" in place.[7] In the author's judgment, with a few exceptions, this remains an accurate assessment today, despite the considerable progress that has been made in improving security and accounting systems at many sites (described in Section III).



This building at the Kurchatov Institute in Moscow, shown before cooperative security upgrades began, holds enough HEU for a nuclear bomb. The barely visible fence is almost entirely overgrown, and there are no sensors or detectors to alert security forces to an intrusion; nor was there any detector to detect authorized workers removing nuclear material.
Source: DOE

The Soviet security system was heavily based on "guards, guns, and gates" at military facilities, and a system in which the manager of each area handling nuclear material took "personal responsibility" for the material in that area. The principal threat the system was designed to address was Western spies. "Insider" nuclear material thieves were not considered to be a major problem, as rigorous personnel reliability programs—careful screening of employees, high pay and status for employees, close KGB surveillance of everyone, and draconian penalties for any detected transgression—were expected to be effective. Moreover, in a closed society in which all contacts with foreigners were carefully monitored by the KGB, even if some one did steal nuclear material, they would have had little prospect of being able to arrange a sale to an interested buyer.[8] Hence, a wide range of technologies used routinely in the West to

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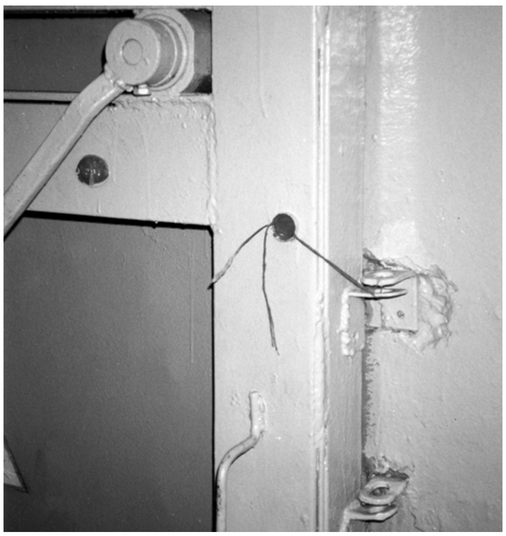
[6] See *MPC&A Program Strategic Plan*, U.S. Department of Energy, January 1998, p. 2 (available at http://www.dp.doe.gov/nn/mpca/frame03.htm).

[7] John Deutch, "The Threat of Nuclear Diversion," testimony before the U.S. Senate, Committee on Governmental Affairs, Permanent Subcommittee on Investigations. *Global Proliferation of Weapons of Mass Destruction*. Part 2. 104th Congress, 2nd Session. S. Hrg. 104–422. March 20, 1996.

[8] For a useful discussion of how the security system dealt with insider threats in Soviet times, and how thinking and practice on this issue is evolving in Russia today, see Irina Koupriyanova, "Russian Perspectives on Insider Threats," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999. Koupriyanova reports, inter alia, that a 1995 analysis of

address the insider threat was not used. Few Soviet facilities were equipped with detectors at the doors that would set off an alarm if some one attempted to smuggle out plutonium or HEU (known as "portal monitors"). Simple wax seals, the same technology that Louis the XIV used to seal his letters, were used to indicate whether containers had been opened or material tampered with, making it a simple task for those with the necessary stamps to open containers, remove material, and reseal the containers with an apparently identical seal. What little there was in the way of alarms, security cameras and the like *within* the buildings relied on open wiring that could easily be cut. While some measurements of material on hand were conducted, these measurements were structured more to contribute to financial accounting and production records than for safeguards and security, and few facilities had accurate and up-to-date measurements of their nuclear material (an essential item if covert thefts are to be detected).[9]



Clay and wax tamper-indicating seals such as the one shown above, in wide use in facilities in the former Soviet Union, can easily be broken and replaced with an identical seal by any worker with an appropriate stamp. Source: DOE

Moreover, purely civilian facilities (where foreign spies were not a major concern) often had little security even if they were working with hundreds of kilograms of weapons-usable material. The author has visited facilities, for example, where the only security was provided by a single seated guard behind a desk at the entrance, who did not bother to check known workers entering and leaving, and the material was secured in a simple locker with a padlock that could have been snapped with a bolt-cutter available at any hardware store. As one senior Russian nuclear official put it to the author in 1994, "at some of these facilities, we have no one guarding but Aunt Masha with a cucumber." When civil war broke out in Georgia, scientists at one facility housing kilograms of HEU took turns guarding the unprotected facility "with sticks and garden rakes."[10]

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theft incidents by the Russian nuclear regulatory agency determined that every single case had involved personnel working within the nuclear material industry; that none of the thefts had been detected by the physical protection system, the containment and surveillance system, or the accounting systems; and that there were no regular assessments of protective system effectiveness against insider threats.

[9] For a useful discussion of how the Russian material accounting system—still largely the system left over from Soviet times—functions and is regulated, see "Material Accounting System Was and Is Still Based on the Principles of Financial Accounting," roundtable discussion, *Yaderny Kontrol Digest* No. 5, Fall 1997. See also David D. Wilkey and Charles R. Hatcher, "Implementation of Materials Accounting in Russia," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999.

[10] Emily Ewell Daughtry and Fred Wehling, "Cooperative Efforts to Secure Fissile Material in the NIS: Shortcomings, Successes, and Recommendations for the Future," *Nonproliferation Review*, forthcoming. This is the Institute of Physics in Tbilisi, Georgia, which at that time had 10 kilograms of 90% enriched HEU. Some of this material was later sold to a similar facility in Uzbekistan, and the rest was removed to the United Kingdom in Project Auburn Endeavor (described below).

Despite years of hard work and considerable progress in cooperative programs to address these threats, most of these problems still exist today. By the end of the year 2000, if all goes well, modern safeguards and security systems will have been completed at facilities housing one-sixth of the weapons-usable material outside of weapons in Russia, leaving work still underway for the remaining five-sixths of the material. While portal monitors have been installed at many facilities, hundreds of tonnes of fissile material is still in buildings that are not equipped with portal monitors. Accurate measured inventories of all nuclear material on hand have still not been carried out at most facilities, and there is still no accurate and up-to-date national inventory system[11]—meaning that if there *were* material missing, it is quite possible that no one would know. Wax seals are still in wide use as tamper-indicating devices.

This padlock – which could be cut in seconds with a bolt-cutter available in any hardware store – secures a room holding weapons-usable nuclear material. Source: DOE

The Russian government has recognized at the highest levels that major upgrades in security and accounting for nuclear materials are needed. In September 1994, President Boris Yeltsin issued a decree calling for a far-reaching interagency effort to improve security and accounting measures, and this was followed by a government-wide order outlining specific tasks signed by Prime Minister Victor Chernomyrdin in early 1995.[12] Unfortunately, however, the government managed to provide only a fraction of the funding needed to carry out the program[13]—and the same has consistently been true for subsequent efforts, as well. New regulations on physical protection of nuclear material have been adopted, and new regulations for material control and accounting have been developed. As recently as 1999, after the shock of the terrorist bombings attributed to Chechens, security against outside attack at nuclear facilities was beefed up[14]—though these measures may not offer much benefit against covert insider theft, which has been the source of all the major thefts of weapons-usable nuclear material to date. At the same time, after initial reluctance, the Russian government in recent years has given

[11] William C. Potter, remarks at the 7th Carnegie International Nonproliferation Conference, Washington DC, January 11-12, 1999 (available at http://www.ceip.org/npp/potter.htm).

[12] Presidential Decree No. 1923, September 15, 1994, "On Priority Measures to Improve the Nuclear Materials Accounting and Protection System," and Resolution of the Government of the Russian Federation No. 34, January 13, 1995, "On Priority Projects for 1995 to Develop and Implement the State Nuclear Materials Control and Accounting System."

[13] See, for example, Duma testimony in "We Cannot Preclude the Possibility of Nuclear Materials Theft," *Yaderny Kontrol*, op. cit. In that hearing, Alexander Dmitriev, deputy chairman of the Russian nuclear regulatory agency, testified that the state program for improving physical protection of nuclear material had received only 20% of its planned funding. First Deputy Minister of Atomic Energy Lev Ryabev testified that implementing the federal program for improving the nuclear materials accounting and control system that had been drawn up for 1997-2001 would cost 150 billion rubles per year (roughly $50 million a year at then-current rates of exchange).

[14] "Russia Tightens Security at Nuclear Plants," *Agence France Press*, October 25, 1999.

The Demand for Black Market Fissile Material

There is significant evidence that both proliferating states and terrorist groups are actively seeking to acquire stolen fissile material for nuclear weapons. Iran, Iraq, Libya, and North Korea, among others, have all been reported to be seeking to acquire such material, as have the Aum Shinrikyo doomsday cult in Japan (recently renamed Aleph), and Osama bin Laden's terrorist organization, Al Qaida. Below, the cases of Iraq, Iran, and the two terrorist groups are described as examples of the broader phenomenon.

Iraq's Saddam Hussein spent billions of dollars attempting to establish an indigenous Iraqi capability to produce fissile material.[1] While such an indigenous production capability was the first choice, after the invasion of Kuwait, when Iraq launched a "crash" program to rapidly produce a single bomb, it planned on using HEU from its safeguarded research reactor. Even after the Gulf War, with the U.N. inspection regime in place, Iraq sought to continue its weapons of mass destruction programs, and built up its foreign procurement network, including its extensive network in the former Soviet Union. Iraq succeeded, for example, in buying gyroscopes taken directly from Russian strategic nuclear missiles, tested and certified by the Russian institutes that had made them. The CIA has warned that Iraq "would seize any opportunity to buy nuclear weapons materials or a complete weapon."[2] Indeed, one of the former leaders of Iraq's nuclear weapons program has described Iraq's efforts to maintain that program after the Gulf War, and warned that Iraq might be able to produce a bomb within months if it acquired fissile material from the former Soviet Union, concluding that "preventing Iraq from acquiring nuclear explosive material abroad, particularly in Russia and former Soviet republics, remains a difficult but absolutely essential goal."[3] Both he and the International Atomic Energy Agency (IAEA) inspectors for Iraq have emphasized that even if the long-term monitoring system once planned for Iraq could be re-established, it might not be able to detect the small-scale effort needed to turn fissile material acquired from abroad into a working bomb.[4]

Iran, too, has sent a substantial network of procurement agents to the former Soviet Union in search of weapons of mass destruction and the means to deliver them, has succeeded in acquiring key missile technologies from Russian institutes, and has specifically sought technologies for producing both HEU and plutonium.[5] The CIA has specifically warned that "Teheran continues to seek fissile material"[6] and reportedly concluded in a recent analysis that it could not rule out the possibility that Iran has already acquired a nuclear weapon capability, if it has succeeded in secretly procuring fissile material abroad.[7] There have been innumerable press reports (of varying levels of credibility) of Iranian attempts to acquire nuclear materials or even nuclear weapons, and there have been a significant number of actual arrests of Iranian nationals, for smuggling of various types of nuclear materials.[8] At the Ulba facility in Kazakhstan, canisters were found labeled for shipping to Teheran, in a room next to the room where hundreds of kilograms of HEU was located. The Iranians had reportedly approached Kazakhstan to secretly purchase beryllium and LEU from this facility, perhaps as a trust-building prelude to an offer to purchase the HEU. (The HEU was subsequently removed from this facility under the U.S.-Kazakh cooperative effort known

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[1] For a useful overview, see Rodney W. Jones and Mark G. McDonough *Tracking Nuclear Proliferation: A Guide in Maps and Charts, 1998,* Washington DC: Carnegie Endowment for International Peace, 1998 (available at http://www.ceip.org/programs/npp/track98b.htm).

[2] John Deutch, then Director of Central Intelligence, testimony to the Permanent Subcommittee on Investigations of the Senate Governmental Affairs Committee, quoted in Jones and McDonough, *Tracking Nuclear Proliferation*, op. cit.

[3] David Albright and Khidhir Hamza, "Iraq's Reconstitution of its Nuclear Weapons Program," *Arms Control Today*, October 1998. See also the interview with Hamza on *60 Minutes II*, CBS News, January 27, 1999, in which Hamza describes Iraqi bribery in Russia to acquire advanced weapons technologies.

[4] See *Sixth Consolidated Report of the Director General of the International Atomic Energy Agency Under Paragraph 16 of UNSC Resolution 1051 (1996),* Vienna, Austria: IAEA, October 8, 1998.

[5] See Jones and McDonough, *Tracking Nuclear Proliferation*, op. cit.

[6] *Unclassified Report to Congress on the Acquisition of Technology Relating to Weapons of Mass Destruction and Advanced Conventional Munitions: 1 January Through June 30, 1999*, Washington DC: Central Intelligence Agency, Nonproliferation Center, February 2, 2000.

[7] See James Risen and Judith Miller, "CIA Tells Clinton an Iranian A-Bomb Can't Be Ruled Out," *New York Times*, January 17, 2000.

as Project Sapphire.)[9] Iran is also purchasing safeguarded civilian nuclear power reactors from Russia—which the United States suspects will be used to build up the technical infrastructure for Iran's weapons program—and has sought to purchase a gas centrifuge uranium enrichment plant from Russia as well. The United States has imposed economic sanctions on some Russian institutes because of their cooperation with Iran on sensitive nuclear technology.

Most terrorist groups have no interest in threatening large-scale destruction. Unfortunately, however, there are a few dangerous exceptions who *do* seek to cause mass destruction, and the possibility that some terrorist groups could actually make a crude nuclear bomb from plutonium or HEU cannot be ruled out.[10] Both Aum Shinrikyo and Osama bin Laden's group have attempted to acquire the necessary materials and technologies—though whether either group would have been able to make a nuclear bomb is highly uncertain.

Aum Shinrikyo carried out a comprehensive program of development for chemical, biological, and nuclear weapons prior to its famous nerve gas attack in the Tokyo subway.[11] Much of Aum's nuclear program, like its chemical and biological programs, seems to have been poorly focused, pursuing efforts such as purchasing a sheep farm with uranium deposits in Australia and stealing confidential documents on laser isotope enrichment, with the idea of producing HEU by the extraordinarily difficult route of mining uranium, purifying it, and using laser enrichment to separate the U-235. At the same time, however, Aum aggressively pursued the possibility of acquiring nuclear technology and material from the former Soviet Union, recruiting thousands of members in Russia, including staff from the Kurchatov Institute in Moscow (a leading nuclear research institute where hundreds of kilograms of weapons-usable HEU were poorly protected and accounted for) and physicists from Moscow State University, and even seeking a meeting with Minister of Atomic Energy Victor Mikhailov to attempt to purchase a nuclear weapon. While Mikhailov refused to meet with Aum, then-Russian Vice President Alexander Rutskoi met with an Aum delegation headed by the cult's leader, Shoko Asahara, in early 1992, and Aum reportedly paid between $500,000 and $1 million to Oleg Lobov, then Secretary of the Russian Security Council, between 1991 and 1995, for reasons that have never been explained. Kiyohide Hayakawa, a leading official of the cult, made repeated trips to Russia on weapons-buying expeditions on the cult's behalf.

Like Aum Shinrikyo, Osama bin Laden's group has attempted to get all types of weapons of mass destruction, but there is little hard evidence that they have succeeded.[12] The U.S. Federal indictment of bin Laden charges that "at various times from at least as early as 1993, Osama bin Laden and others known and unknown, made efforts to obtain the components of nuclear weapons." Similarly, a criminal complaint lodged against Mamdouh Mahmud Salim, one of bin Laden's top lieutenants, charged that in 1993 he had approved the attempted purchase of enriched uranium "for the purpose of developing nuclear weapons." Some reports suggest Bin Laden's group may have attempted to purchase nuclear material through contacts in Ukraine and in the Central Asian republics of the former Soviet Union. Unfortunately, the information needed to make a nuclear bomb with the fissile material in hand is now widely available. Should fissile material become readily available on a nuclear black market, hostile proliferating states and terrorist groups would have access to the last essential ingredient for acquiring nuclear bombs, potentially posing terrifying new threats with virtually no warning.

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[8] See, for example, the subscription-only nuclear trafficking database maintained by the Center for Nonproliferation Studies at the Monterey Institute of International Studies (http://cns.miis.edu), which contain countless incidents involving Iranian nationals.

[9] See discussion in William C. Potter, "Project Sapphire: U.S.-Kazakhstani Cooperation for Nonproliferation," in Shields and Potter, *Dismantling the Cold War*, op. cit.

[10] For a useful unclassified discussion of the possibility that terrorists could build nuclear explosives, see J. Carson Mark et al., "Can Terrorists Build Nuclear Weapons?" in Paul Leventhal and Yonah Alexander, eds., *Preventing Nuclear Terrorism.* Lexington MA: Lexington Books, 1987. For discussions of the incentives and disincentives for terrorists to acquire and use weapons of mass destruction, and specifically nuclear weapons, see, for example, Richard A. Falkenrath, Robert D. Newman, and Bradley A. Thayer, *America's Achilles' Heel: Nuclear, Biological, and Chemical Terrorism and Covert Attack*, Cambridge MA: MIT Press for BCSIA Studies in International Security, 1998; and Jessica Stern, *The Ultimate Terrorists*, Cambridge MA: Harvard University Press, 1999.

[11] The account below is largely based on Gavin Cameron, "Multi-Track Micro-Proliferation: Lessons from Aum Shinrikyo and Al Qaida," *Studies in Conflict and Terrorism*, Vol. 22, No. 4, 1999, and sources cited therein.

[12] Ibid.

increasingly broad support to cooperation with the United States designed to help address these issues (discussed in Section III).

The economic crisis in Russia following the August 1998 financial meltdown exacerbated the security problems that were already evident. Guards at many facilities—most of whom had very little knowledge of the importance of the material they were guarding, or training in nuclear matters—were not paid for months at a time. Guards at some facilities were observed leaving their posts to forage for food, or refusing to patrol freezing perimeters because they had not been issued warm winter uniforms. At some facilities, electricity—the lifeblood of the alarms and other security systems—was occasionally shut off because the facilities had not been able to pay their electricity bills. At a number of facilities, security equipment installed with U.S. assistance was simply not being used, because there was no money to operate and maintain it. The economic crisis, in short, was making the situation worse faster than U.S. assistance and Russia's unilateral efforts were making it better.[15] (Russian experts report, however, that these kinds of incidents had been taking place for some time, and had become virtually a normal part of life at Russian nuclear facilities; the August 1998 events only exacerbated an existing situation.)

At least for facilities within the Ministry of Atomic Energy (MINATOM), however, this emergency situation had largely stabilized by early 1999, as the banks had resumed functioning, the decline of the ruble had made the Ministry's hard-currency export income go farther domestically, and collections of payments for electricity produced at nuclear plants had modestly improved.[16] During the course of 1999, the Russian government's financial picture was further improved by the substantial increase in the price of oil, Russia's largest export commodity, and the return of a modest rate of economic growth in Russia.

DOCUMENTED THEFTS OF WEAPONS-USABLE MATERIAL. As a result of these changed security conditions since the collapse of the Soviet Union, there have been a number of documented cases of theft of substantial quantities of weapons-usable nuclear materials. Key confirmed cases include: 1.5 kilograms of weapon-grade HEU from the "Luch" production association in Podolsk, Russia, in 1992; 1.8 kilograms of 36 percent enriched HEU from the Andreeva Guba naval base near Russia's Norwegian border in July 1993; 4.5 kilograms of material enriched to over 19 percent U-235 from the Sevmorput naval shipyard near Murmansk in November 1993; over 360 grams of plutonium seized in Munich on a plane from Moscow as a result of a German "sting" operation in August

[15] See, for example: Bill Richardson, "Russia's Recession: The Nuclear Fallout," *Washington Post*, December 23, 1998; Kenneth N. Luongo and Matthew Bunn, "A Nuclear Crisis in Russia," *Boston Globe*, December 29, 1998; Todd Perry, "Securing Russian Nuclear Materials: The Need for an Expanded U.S. Response," *Nonproliferation Review*, Winter 1999, Vol. 6, No. 2; and William C. Potter, "Prospects for U.S.-Russian Collaboration for Nonproliferation in the Post-Cold-War Era," presentation to the Defense and Security Committee of the North Atlantic Assembly, 44th Annual Session, Edinburgh, November 10-13, 1998. For a referenced listing of specific incidents suggesting a serious problem in security during this period, see Matthew Bunn, "Loose Nukes Fears: Anecdotes of the Current Crisis," December 5, 1998 (available at http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/atom).

[16] Interview with senior MINATOM official, February 1999. Also interviews with senior nuclear scientists from the closed nuclear cities, October 1999.

1994; and 2.73 kilograms of essentially weapon-grade (87.7 percent U-235) HEU seized in Prague in December 1994.[17]

It is widely thought that there have been no cases since then involving directly weapons-usable material, but this is not the case.[18] As recently as late 1998, for example, the Russian Federal Security Service (FSB, successor to the KGB) revealed the first known case that apparently involved a conspiracy to steal enough nuclear material for a bomb at a single stroke. The conspirators—who were stopped before the material actually left the facility—tried to steal 18.5 kilograms of radioactive material described as suitable for the "production of components of nuclear weapons" from a major MINATOM facility in the Chelyabinsk region (which include the nuclear weapons design laboratory at Snezhinsk, the plutonium and HEU processing plant at Ozersk, and the nuclear weapons assembly and disassembly facility at Trekhgorny). MINATOM's chief of nuclear material accounting later confirmed the FSB's account, and warned that the theft, if successful, could have inflicted "significant damage on the [Russian] state." While the Russian government has not confirmed the specific type of material involved in this case, one can conclude with considerable confidence that it was either plutonium or HEU, based on (a) the statement that it was radioactive material that can be used to make nuclear weapons components; (b) the quantity of material involved (which effectively rules out a variety of other radioactive materials used in weapons, such as tritium or polonium); (c) the conclusion that theft of this amount of material would be enough to cause significant damage to the state; and (d) another MINATOM statement that the material could be used to make products for either the military or the civilian nuclear industry (which is true of both plutonium and HEU, but of few other radioactive materials likely to be available in quantities of tens of kilograms at a time). This makes this case by far the largest documented attempt to steal weapons-usable material in the former Soviet Union.[19]

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[17] For a useful discussion of some of these cases, see William Potter, "Before the Deluge? Assessing the Threat of Nuclear Leakage From the Post-Soviet States," *Arms Control Today,* October 1995, pp. 9–16.

[18] For a useful discussion of the apparent gap in cases in the last half of the 1990s, see Emily Ewell, "NIS Nuclear Smuggling Since 1995: A Lull in Significant Cases?" *The Nonproliferation Review*, Spring-Summer 1998.

[19] For the original announcement, see "FSB Agents Prevent Theft of Nuclear Material in Chelyabinsk," *ITAR-TASS*, December 18, 1999. The chief of the FSB for the Chelyabinsk region, Major General Valeriy Tretyakov, expressed "concern" about security for nuclear material at nuclear facilities in the region, and said that while U.S. MPC&A assistance was helpful, it was "far from being [the] permanent measure we need." (See also Monterey Institute for International Studies, Center for Nonproliferation Studies, Nuclear Smuggling Database [http://cns.miis.edu/db/nistraff/index.htm], Document 19980790, quoting Alevtina Nikitina, "Komu vygodno razrusheniye FSB?" *Chelyabinskiy rabochiy*, 19 December 1998.) In late 1999, this incident was confirmed by the head of MINATOM's material accounting department, Victor Yerastov, in a published interview. In one translation, Yerastov described the material as "a sort of semi-finished product made of fissile material," which "can be used in the manufacture of various military and civilian products in the nuclear industry," and said that if the theft had succeeded, it "it could have inflicted a significant damage to the [Russian] state." (See "Interview: Victor Yerastov: MINATOM Has All Conditions for Providing Safety and Security of Nuclear Material," *Yaderny Kontrol Digest*, Vol. 5, No. 1, Winter 2000.) Oleg Bukharin, however, indicates that in the original Russian, Yerastov used a phrase meaning "nuclear material" rather than "fissile material." (Personal communication, January 5, 2000.) Yerastov reports that "the attempt to steal this material was prevented at the very beginning, on the enterprise territory, and we do not find it correct to say that the theft occurred." In the interview, Yerastov

Sizing the Problem

While the problems posed by Russia's nuclear infrastructure are enormous, they are not infinite. A few basic calculations provide useful bounds for thinking about the magnitude of the problem.

Costs of safeguards and security. The weapons-usable nuclear materials in the former Soviet Union are believed to exist in nearly 400 buildings at nearly 60 sites. If there was no progress at all in consolidating this material at fewer sites, and it cost $10 million, on average, to upgrade security and accounting for each of these buildings,[1] the total cost of these upgrades would be in the range of $4 billion. If the roughly 40 small sites required an average of 100 guards each, and the roughly 20 very large sites required an average of 2000 guards each, and each guard was paid $500 a month (substantially more than current salaries), the total cost of guarding all of these facilities (again assuming no consolidation) would be over $250 million per year. If security and accounting costs other than the guard forces added another 50 percent, the total cost would be in the range of $400 million per year. These are large numbers, but not outlandish ones. Russia receives more than $600 million each year from income on the HEU deal alone. The United States spends roughly $700 million a year on the broad spectrum of safeguards and security activities (not just guarding fissile material) in the DOE complex.

Costs for paying nuclear weapons complex employees. There are approximately 150,000 total employees in MINATOM's nuclear weapons complex. Currently, on average, they are reportedly paid less than $100 per month.[2] The total payroll for MINATOM's entire nuclear weapons complex is therefore in the range of $180 million a year—again, far less than what Russia takes in each year from the HEU deal alone (though not all of those funds go to MINATOM). The average age of these workers is now in the 50s, and the average male life-expectancy in Russia is roughly 58 years (though workers at these nuclear facilities apparently tend to live somewhat longer), suggesting that in the extreme case of offering lifetime "buyouts" to everyone, the total cost for paying for *all* of the Russian nuclear weapons complex workers to retire on full salary for the rest of their lives would probably be in the range of $2-$4 billion. Of course, some of these workers could be paid to work on decommissioning and cleaning up the sites where they used to work on producing weapons and materials, rather than being paid to retire. Such a combination of buy-outs to encourage early retirement and engaging workers in cleanup is, in effect, the approach that has been taken in shrinking the nuclear weapons complex in the United States—but Russia has not had the funds to pursue a similar strategy.

Commercial value of Russia's total stockpiles of fissile material. As noted in the text, Russia is believed to have roughly 1350 tonnes of fissile material. At the $12 billion for 500 tonnes price originally negotiated for the HEU Purchase Agreement, the value of the entire stockpile, including all the material in all of Russia's nuclear weapons, would be in the range of $26 billion—less than the costs of many of the new weapon systems currently planned by the U.S. Department of Defense.

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[1] See similar estimate in CBO, *Cooperative Approaches*, op. cit.
[2] Khripunov, "MINATOM on the Edge," op. cit.

Another incident, where the material was found to be missing in the late 1990s (though the theft may have occurred earlier), involves the only confirmed case where the weapons-usable material is still missing. This occurred at the Sukhumi research center in the Abkhazia region of Georgia, where 2 kilograms of 90 percent enriched HEU was once located. An accounting for the HEU was last conducted in 1992. In 1993, as a result of the Abkhaz civil war, the scientists fled the facility. Neither Georgian nor Russian

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also says that there was a case of fissile material theft (explicitly distinguished from thefts of other types of nuclear material) at a MINATOM enterprise in 1995, while the last previously confirmed seizure had taken place in 1994. Yerastov attributed the decline in thefts since 1995 to a combination of a decline in press exaggeration of the prices available to thieves, unilateral Russian government efforts to improve security, and international MPC&A cooperation, particularly with the United States.

officials were able to visit the facility again until 1997, when a Russian team found the facility abandoned and the HEU gone. To this day, no one knows where this HEU went; it may be in the hands of the Abkhaz separatists, or it may have been stolen by or sold to others.[20]

In short, theft and smuggling of the essential ingredients of nuclear weapons is not just a possible risk for the future, it is an ongoing reality. Were it not for the intense patriotism and devotion to duty of the vast majority of the nuclear scientists and workers in the former Soviet states, it seems likely that a genuine nuclear proliferation catastrophe would have occurred already. But everyone has a breaking point, and no one can know how long that remarkable bulwark protecting the world from proliferation will last. Unless further actions are taken urgently, the danger that potential nuclear weapons materials will yet fall into the hands of terrorists or proliferating states will remain unacceptably high.

Nuclear Weapons

Security for nuclear materials in weapons in Russia is substantially better than for the "loose" materials just discussed, for reasons relating both to the fundamental nature of nuclear weapons and to the organizational arrangements for their protection.[21] All of the estimated 17,000-22,000 former Soviet nuclear weapons that still exist have been consolidated within Russia.[22] (Successfully working with the former Soviet states to make this come about was one of the unsung nonproliferation success stories of the Clinton administration.) In Russia, management and security for nuclear weapons is the responsibility of the 12th Main Directorate of the Ministry of Defense, a trained, professional force of roughly 30,000, of whom 45% are officers.[23] People working with nuclear weapons are carefully screened, and a "three-man rule" is in place forbidding anyone from working with nuclear weapons either alone or even in a group of two. Nuclear weapons are relatively large, heavy objects; unlike weapons-usable nuclear material, one cannot simply carry them out in a briefcase or under one's overcoat.

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[20] This incident is described on the subscription-only web page of the Center for Nonproliferation Studies at the Monterey Institute for International Studies, at http://cns.miis.edu/db/nisprofs/georgia/facils/vekua.htm. See also Daughtry and Wehling, "Cooperative Efforts," op. cit.

[21] For a detailed discussion of Russian nuclear weapon storage facilities and storage practices, see Joshua Handler, *Russian Nuclear Warhead Dismantlement Rates and Storage Site Capacity: Implications for the Implementation of START II and De-Alerting Initiatives*. Princeton, NJ: Princeton University Center for Energy and Environmental Studies, CEES Report No. AC-99-01, February 1999.

[22] In 1997, Gen. Eugene Habiger, then commander of U.S. Strategic Command, estimated that there were 20,000-25,000 warheads remaining in Russia. (Testimony to the Senate Armed Services Committee, March 13, 1997). A year later, Habiger referred to 17,000-22,000 as being the number of tactical nuclear warheads alone in Russia, but from other sources it appears that this was a mis-description of the U.S. estimate of the *total* Russian nuclear warhead stockpile after some additional dismantlement had taken place. See testimony before the Senate Armed Services Committee, March 31, 1998, in *FY1999: Strategic Forces*, S. Hrg. 105-605, pt. 7. See also William Arkin, Robert Norris, and Joshua Handler, *Taking Stock: Worldwide Nuclear Deployments, 1998.* Washington, D.C.: Natural Resources Defense Council Nuclear Program, 1998.

[23] "Interview: Igor Valynkin: We'll Do Our Best to Prevent Incidents Like That One at the Novaya Zemlya Test Site," *Yaderny Kontrol (Nuclear Control)*, Vol. 42, No. 6, November-December, 1998 (Center for Policy Studies in Russia, Moscow).

Similarly, nuclear weapons are easily countable: the commander of a storage unit is very much aware of whether there are 99 or 100 weapons in his charge. Inventories are taken regularly, and security forces are regularly tested against a mock terrorist team that attempts to break in.

As the Soviet Union moved toward collapse, the Soviet military rapidly reduced the number of nuclear weapon storage sites, from 500 in the 1980s to 65-80 today, eliminating the risks and costs of having such weapons stored at large numbers of small sites.[24] In 1997, Gen. Eugene Habiger, then-commander of the U.S. Strategic Command, led the first American delegation allowed to tour an active Russian nuclear weapons storage facility and view the security procedures there. Habiger declared himself "impressed," saying that the Russians "go to great lengths" to provide security for nuclear weapons, and that "if what I saw was representative, yes, I have confidence in the safety and security of their nuclear weapon stockpile."[25] Similarly, the CIA concluded in 1996 that security for nuclear weapons in Russia remained effective, in contrast to its conclusions with respect to Russian nuclear material.[26] Despite myriad claims and exaggerated press accounts, there are no confirmed cases of theft or attempted theft of actual nuclear weapons.[27]

Nevertheless, even in the case of nuclear weapons, there are grounds for concern. The top leadership of the 12th Main Directorate have testified to the Russian Duma that funding for nuclear weapons security is grossly inadequate[28] (with the 12th Main Directorate's budget apparently only half as large as U.S. assistance for Russian warhead security).[29] As the CIA has pointed out, "the threat [of theft] from within the Russian military and the deteriorating economy" mean that the judgment that nuclear weapons

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[24] See Department of Defense, *Proliferation: Threat and Response*, November 1997, p. 43; Joshua Handler, "Lifting the Lid on Russia's Nuclear Weapon Storage," *Jane's Intelligence Review*, August 1, 1999; and Handler, *Russian Nuclear Warhead Dismantlement Rates,* op. cit.

[25] Habiger noted, however, that he had seen only one facility; he observed others on a later visit. Habiger pointed out that the Russians used a somewhat different approach relying more on people and less on high technology. See Gen. Eugene Habiger, "Special Defense Department Briefing," *Federal News Service*, November 4, 1997; for the later trip, see Gen. Eugene Habiger, "News Briefing," *Federal Document Clearing House News Transcripts,* June 16, 1998.

[26] Deutch, testimony in *Global Proliferation of Weapons of Mass Destruction*, op. cit.

[27] Perhaps the most disturbing allegations of missing nuclear weapons originated with former Russian National Security Advisor Alexander Lebed, who indicated in several discussions and interviews that while national security advisor to President Yeltsin, he had ordered an accounting of the "suitcase bombs" in the Russian arsenal, and that scores of these weapons were unaccounted for. Lebed's charge that such suitcase bombs existed was backed by the anti-nuclear environmental expert Alexander Yablokov, who had been Yeltsin's environmental adviser early in Yeltsin's term, but the Ministries of Defense and Atomic Energy strongly denied that any weapons could be missing, and Lebed later appeared to back off many of his original charges himself. For an extended discussion of this episode, see Scott Parish and John Lepingwell, *Are Suitcase Nukes on the Loose?* Monterey, CA: Center for Nonproliferation Studies, Monterey Institute of International Studies, 1998 (available at http://cns.miis.edu/pubs/reports/lebedlg.htm). For Lebed's seeming retraction, see Pavel Felgengauer, "Lebed Backpedals on Allegedly Missing 'Suitcase' Nuclear Devices," *St. Petersburg Times*, October 13-19, 1997. The full text of the interview quoted by Felgengauer was posted in October 1997 at the www.msnbc.com web site, and is available from the author on request.

[28] For an edited English translation of the transcript, see *Yaderny Kontrol Digest*, No. 5, Fall 1997.

[29] See statement by Gen. Igor Valynkin, commander of the 12th Main Directorate, quoted in "Valynkin Thanks Nunn-Lugar for Russian Nuclear Safety," *Yaderny Kontrol Digest*, No. 10, Spring 1999 (available at http://www.pircenter.org/yke/index.htm).

remain secure "could change rapidly."[30] Crime is rising rapidly in the Strategic Rocket Forces, and the violent incident in September 1998 when several 12th Main Directorate soldiers murdered one of their comrades, took hostages, and attempted to hijack an aircraft suggests that the severe stresses permeating the Russian military in the wake of the August 1998 financial meltdown have been felt within the force that guards nuclear weapons as well.[31] In October 1998, the commander of the 12th Main Directorate, while emphasizing that there was no need for concern over the security of Russian nuclear warheads, acknowledged that the directorate's troops had not been given any higher priority in receiving pay than other troops, that they had received the paychecks due them only through July, and that the directorate was helping officers to get vegetables and potatoes for the winter in lieu of cash.[32]

Underfunding an Oversized Complex

Concerns over security for nuclear weapons and materials are seriously exacerbated by Russia's maintenance of a nuclear complex—both civilian and military—vastly larger than the available funding can support, and vastly larger than needed for the complex's post-Cold War missions. Russia will inevitably maintain a significant arsenal of nuclear weapons for many years to come, and as long as it does so, will continue to have a legitimate need for a nuclear weapons complex sufficient to maintain that arsenal and keep it safe and secure. But such a complex could be far smaller than the one that now exists.

Today, there remain ten entire cities, home to three quarters of a million people, built only for the purpose of designing and producing nuclear weapons or producing nuclear material for them, closed off from the outside world by barbed wire and armed troops. While these cities once got the best of everything the Soviet Union had to offer, their funding has collapsed with the end of the Cold War, and pay there is both meager and intermittent; government funding for the defense activities of the Ministry of Atomic Energy has been cut to one-seventh its previous level.[33] Yet the nuclear facilities in these cities still employ some 150,000 people—whose pay, on average, is now less than $100

[30] Deutch, testimony in *Global Proliferation of Weapons of Mass Destruction*, op. cit.

[31] For press accounts of this incident, see Bill Gertz, "Yeltsin Orders Nuclear Security Probe," *The Washington Times*, October 21, 1998, and Vladimir Georgiev, "Underlying Reason: Crime in the Russian Army Has Rolled up to Nuclear Munitions Units, But the Ministry of Defense Believes Russia Is Capable of Controlling Weapons of Mass Destruction Without Foreign Intervention," *Moscow Nezavisimoye Voyennoye Obozreniye*, September 11-17, 1998 No.34, p. 1, translated in Foreign Broadcast Information Service, Central Eurasia, September 23, 1998. For an official reaction from the commander of the 12th Main Directorate, see "Interview: Igor Valynkin: We'll Do Our Best to Prevent Incidents Like That One at the Novaya Zemlya Test Site," op. cit.

[32] "Russia is capable to ensure its security, general," *ITAR-TASS*, October 9, 1998. According to Russian officials, a statement in October that troops have only received pay for July means that they are receiving paychecks with some regularity, but that the paychecks they received recently only bring them up to what they were supposed to have been paid by July; it does *not* necessarily mean that they have received no pay at all since July.

[33] First Deputy Minister of Atomic Energy Lev Ryabev, "The Role of the NCI in Meeting Russia's Nuclear Complex Challenges," remarks to the 7th Carnegie International Nonproliferation Conference, Washington DC, January 11-12, 1999 (available at http://www.ceip.org/programs/npp/ryabev992.htm).

per month.[34] In late 1996, Vladimir Nechai, director of one of Russia's two premier nuclear weapons laboratories, committed suicide, in part in desperation over his inability to pay his employees' salaries.[35] In November, 1998, 3,000 workers at Nechai's institute went on strike, protesting "constant undernourishment, insufficient medical service, [and] inability to buy clothing and footwear for children or to pay for their education."[36] The following month, an employee at Russia's other leading nuclear weapons design institute was arrested for spying for Iraq—in this case, on advanced non-nuclear weapons—a development the regional head of the successor agency to the KGB blamed on the "very difficult financial position" facing Russia's nuclear experts.[37]

The situation for many civilian nuclear facilities is even worse—particularly for small, isolated research labs which no longer have the funding to do the research or to provide adequate protection for the material they still have on hand. In visits to a wide variety of nuclear facilities following the August financial meltdown in 1998, the increasing desperation that erodes the performance of security systems while simultaneously increasing temptations for theft was starkly evident.[38] In September, 1998, the Russian Minister of Atomic Energy, responding to thousands of nuclear workers protesting unpaid wages, said that the government owed the Ministry over $170 million and had not provided a single ruble in two months.[39] Thus, the threat includes not only weaknesses in technical security and accounting systems, but also the profound destabilization of the lives of the guards and workers who have access to or provide

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[34] Igor Khripunov, "MINATOM At the Edge," *Bulletin of the Atomic Scientists*, May/June 1999, estimated $60/month; Minister of Atomic Energy Yevgeniy Adamov reported in the spring of 1999 that average salaries for nuclear industrial workers were 1,800 rubles per month, and for scientists approximately 1,400 rubles per month, corresponding to $80 and $60 respectively at then-current rates of exchange (see "MINATOM Reviews 1998, Making Plans for 1999," *Yaderny Kontrol Digest*, No. 10, Spring 1999).

[35] For discussions of the status of the Russian nuclear weapons complex, see Matthew Bunn, Oleg Bukharin, Jill Cetina, Kenneth Luongo, and Frank von Hippel, "Retooling Russia's Nuclear Cities," *Bulletin of the Atomic Scientists*, September/October 1998; Khripunov, "MINATOM at the Edge," op. cit.; Susan S. Voss et al., "Overview of Minatom's Ten Closed Nuclear Cities," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999; *The Nuclear Cities Initiative: Status and Issues*, Washington DC: Russian-American Nuclear Security Advisory Council (RANSAC), January 1999; and Jill Cetina, Oleg Bukharin, and Frank von Hippel, *Defense Conversion and Small Business Development: A Proposal for Two IFC Projects in Three of Russia's Closed Nuclear Cities*, Princeton, NJ: Center for Energy and Environmental Studies, Princeton University, Report 306, March 1998. For a detailed description of the sites in the closed nuclear complex, with declassified U.S. intelligence satellite photographs of the sites, see Oleg A. Bukharin, Thomas B. Bukharin, and Robert S. Norris, *New Perspectives on Russia's Ten Secret Cities,* Washington DC: Natural Resources Defense Council, Nuclear Weapons Databook Working Papers, October 1999; that paper serves as an update of the book by the same authors, *Making the Russian Bomb: From Stalin to Yeltsin,* Boulder, CO: Westview, 1995, which has the most detailed unclassified descriptions of many of these facilities available.

[36] Yevgeni Tkachenko, "Ural Nuclear Workers on Strike, Demanding Wage Arrears," *ITAR-TASS*, November 19, 1998. For a listing of this and many other incidents from the same period, see Bunn, "Loose Nukes Fears," op. cit.

[37] "Nuclear Center Worker Caught Selling Secrets," *Russian NTV*, Moscow, 16:00 Greenwich Mean Time, December 18, 1998, translated in *BBC Summary of World Broadcasts,* December 21, 1998.

[38] For one published account, see Potter, "Prospects for U.S.-Russian Collaboration for Nonproliferation," op. cit.

[39] David Hoffman, "Russia's Nuclear Force Sinks With the Ruble: Economic Crisis Erodes Strategic Arsenal," *The Washington Post,* September 18, 1998.

security for nuclear weapons and materials. Their patriotism and dedication to duty, even in the face of unpaid wages and shortages of everything from food to medicine—combined with the continuing fear of the consequences of being caught—have been critical factors limiting the scale of nuclear theft and leakage of nuclear weapons information to date.

Unpaid nuclear workers protesting in Moscow. Average salaries in the nuclear sector in Russia are less than $100 per month, and sometimes go unpaid for months at a time: at some facilities, unpaid nuclear guards have left their posts to forage for food. Source: AP

Secrecy

All of these urgent security hazards are taking place within a nuclear complex that remains shrouded in secrecy. Of course, there are many nuclear secrets that must be protected to prevent proliferation and avoid revealing vulnerabilities. But the scale of nuclear secrecy that still exists in Russia goes well beyond those requirements, reflecting the legacy of decades of Communist obsession with secrecy, and centuries of tsarist secrecy before that.

After a period immediately following the collapse of the Soviet Union when a substantial amount of new information was released, and Russia seemed positively inclined to pursue nuclear transparency, the opponents of nuclear openness in Russia appear to have regained the upper hand. This pervasive secrecy—symbolized by Alexander Nikitin's arrest and trial for espionage for helping to compile publicly available information relating to the environmental problems of the Russian nuclear navy—poses substantial barriers to cooperation to improve security, and even more fundamental obstacles to the kinds of monitoring and openness that would be required to verify deep reductions in nuclear warhead stockpiles. With the recent deterioration of U.S.-Russian political relations, the increased constraints on Russian access to U.S. nuclear facilities in the wake of the Chinese espionage scandals, and the ascension of a former security service chief to the Presidency, the Russian security services have cracked down harder during 1999, significantly constraining a variety of types of sensitive U.S.-Russian cooperation on nuclear issues, and harassing or arresting a number of environmentalists and arms control experts.

An enormous range of nuclear issues remains shrouded in secrecy, not subject to any form of international verification or cooperation. It is not widely understood, for example, that arms control agreements to date have focused only on delivery vehicles and launchers; once warheads were removed from delivery vehicles, there has been no requirement that they be dismantled, or even accounted for. The United States has never verified the dismantlement of a single Russian nuclear warhead, or provided a penny of assistance directly for warhead dismantlement. Similarly, Russia has never been permitted to verify the dismantlement of a single U.S. warhead. Nor have the two countries ever told each other how many warheads they now have, how many they plan to retain under future arms control agreements, or how large their stockpiles of fissile material are (though Presidents Clinton and Yeltsin agreed to such a stockpile data exchange in September 1994).

Indeed, excessive secrecy is a barrier that both countries, not just Russia, must address. In both the United States and Russia, for example, the total number of nuclear weapons in the stockpile—to say nothing of the breakdown by specific types—remains a closely guarded secret, though revealing these figures could not possibly undermine either country's security. In the United States, at least some substantial first steps have been taken toward eliminating unnecessary Cold War secrecy: large areas of the nuclear facilities have been opened to visitors, vast arrays of safety-related information has been made public, and a number of important facts about the stockpile—the total quantity of plutonium (and the breakdown of this plutonium stock by location, grade, and form), the average isotopics of plutonium used in weapons, the number of nuclear weapons dismantled year by year, and, soon, the details of the HEU stockpile—have been declassified and made available both to the public and to Russia and other foreign powers.[40] (Prospects for further reductions in nuclear secrecy in the United States appear slim, however, in the wake of the recent scandals surrounding alleged Chinese nuclear espionage.[41]) All of this information remains secret in Russia, and access even to the cities surrounding the facilities where nuclear weapons work is done remains closely controlled. No American, for example, has ever set foot in the plants where nuclear weapons assembly and disassembly work takes place in Russia. Restrictions on access and information at other facilities are so far-reaching that in some cases it has been impossible to judge which buildings at a facility require security upgrades, as the Russian experts at the facility cannot openly provide accurate information on what types of materials the buildings contain. In some cases, even the location of the building or facility to be upgraded is considered a state secret.

As a result, U.S. estimates of the size of the Russian warhead stockpile are officially judged to be uncertain to plus or minus 5,000 warheads, estimates of the size of the Russian fissile material stockpile are uncertain to more than a hundred tonnes, and assessments of the security situation at individual facilities are based on information that ranges from nearly complete to virtually nonexistent. In many cases, the continuing shroud of secrecy poses enormous obstacles to cooperation that would benefit both sides' security.

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[40] For a review of the U.S. Openness Initiative, see Jennifer Weeks, "Will the O'Leary Legacy Last?" *Bulletin of the Atomic Scientists*, March/April 1998 (available at http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/atom). The text of the various documents released during the course of the U.S. Openness Initiative can be found at http://www.osti.gov/opennet/. Remarkably, the Department of Energy has compiled a list of all the declassified facts related to nuclear weapons design and made it available on the internet. See *Drawing Back the Curtain of Secrecy: Restricted Data Declassification Decisions, 1946 to the Present,* Washington DC: Department of Energy, Office of Declassification, Report RDD-5, January 1, 1999 (available at http://www.doe.gov/opennet/rdd-5.html).

[41] "Secrecy vs. Openness: Finding a Balance at the Department of Energy," Proceedings of a Workshop, Harvard University, Project on Managing the Atom, November 29, 1999, forthcoming.

Russia's Closed Nuclear Cities

Name	Population[1]	Nuclear Workforce	Main Defense Role
Sarov (Arzamas-16)	83,000	21,500[2]	Weapons design; small weapons assembly/ disassembly facility
Snezhinsk (Chelyabinsk-70)	48,000	15,000[3]	Weapons design
Zheleznogorsk (Krasnoyarsk-26)	100,000	9,500[4]	Plutonium production, reprocessing
Ozersk (Chelyabinsk-65)	88,000	18,000[5]	Plutonium and tritium production, plutonium and HEU weapon component fabrication, reprocessing
Seversk (Tomsk-7)	119,000	15,000[6]	Plutonium production, HEU enrichment, plutonium and HEU weapon component fabrication, reprocessing
Novoural'sk (Sverdlovsk-44)	96,000	19,000[7]	HEU enrichment
Zelenogorsk (Krasnoyarsk-45)	67,000	13,000	HEU enrichment
Lesnoy (Sverdlovsk-45)	58,000	15,500[8]	Weapons assembly/ disassembly
Zarechnyy (Penza-19)	64,000	17,000	Weapons assembly/ disassembly
Trekhgornyy (Zlatoust-36)	33,000	9,000	Weapons assembly/ disassembly
Total:	756,000	140-160,000[9]	

[1] All population figures from First Deputy Minister of Atomic Energy Lev Ryabev, "The Role of the NCI in Meeting Russia's Nuclear Complex Challenges," remarks to the 7th Carnegie International Nonproliferation Conference, Washington DC, January 11-12, 1999 (available at http://www.ceip.org/programs/npp/ryabev992.htm).
[2] This includes 18,000 employees at the nuclear weapons design laboratory, and 3,500 at the Avangard nuclear weapons assembly/disassembly facility. See James W. Toevs, "Sarov, Russia: The Sarov Demonstration Project," presentation to the Forum on the European Nuclear Cities Initiative, Rome, December 12-13, 1999.
[3] Population and workforce figures from Snezhinsk Web page (www.ch70.chel.su), April 12, 1997.
[4] Workforce figure provided by Krasnoyarsk-26 Deputy Director Yuri Revenko, in a discussion on May 24, 1997. Revenko indicated that the workforce is declining.
[5] Workforce figure provided by Deputy Minister of Atomic Energy Lev Ryabev in a discussion on May 24, 1997. Ryabev indicated that 1,500 of these workers are employed at the RT-1 reprocessing plant.
[6] Workforce figure provided by Tomsk-7 Director Gennadi Khandorin in a discussion on May 24, 1997. Khandorin indicated that the workforce had declined substantially in the early 1990s, but that the current workforce was 30 percent higher than at its minimum in 1994, as a result of commercial contracts.
[7] Workforce figures for Novoural'sk and Zelenogorsk are estimated on the basis of the average 5-1 ratio of population to nuclear workforce in the other nuclear cities.
[8] In an interview on May 24, 1997, Deputy Minister of Atomic Energy Lev Ryabev indicated that approximately 45,000 people work at the four Russian nuclear weapons assembly/dismantlement facilities. The estimates here are based on assuming that the Avangard plant at Sarov employs 3,500 of these 45,000 (see above), and assigning the remaining workforce proportionally to the populations of those towns.
[9] A range is provided to indicate the uncertainties in the available data. Ryabev ("Role of the NCI," op. cit.) indicated that of these, 75,000 were employed directly in defense work, to be cut to 40,000 by 2005.

Excessive Stockpiles and Continued Production

With the end of the Cold War, Russia and the United States both have far more nuclear warheads than they could possibly need, and far more plutonium and HEU than needed even to support those bloated warhead stockpiles. According to unclassified estimates, the United States still possesses over 12,000 nuclear weapons, and is planning to retain some 10,000 of these (counting both strategic and tactical weapons, both those deployed and those in reserve) even when the START I and START II arms reduction treaties are fully implemented.[42] The United States has an estimated stockpile of nearly 100 tonnes of plutonium and some 645 tonnes of HEU.[43] As noted earlier, Russia is believed to have 17,000-22,000 nuclear weapons remaining, and unclassified U.S. estimates suggest that it has 160 tonnes of separated plutonium (counting both military and civilian stockpiles), and 1050 tonnes of HEU.[44] These remaining plutonium and HEU stockpiles would be sufficient to support a rapid return to Cold War levels of armament. It is this fact, combined with the risks of nuclear theft posed by maintaining such vast stockpiles in readily weapons-usable form, that makes disposition of nuclear materials an urgent security issue for the United States.

Yet in Russia, production of new weapons plutonium continues, at a rate of approximately 1.5 tonnes per year—not because Russia needs or is using the plutonium for new weapons, but because the reactors that produce it also produce essential heat and power for nearby communities. Similarly, Russia's civilian spent fuel reprocessing enterprise continues to operate at the RT-1 plant at Mayak, separating somewhat less than a tonne of reactor-grade (but weapons-usable) plutonium each year to add to the 30-tonne

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[42] See William Arkin, Robert Norris, and Joshua Handler, *Taking Stock: Worldwide Nuclear Deployments, 1998*, Washington, DC: Natural Resources Defense Council Nuclear Program, 1998.

[43] See David Albright, Frans Berkhout, and William Walker, *Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities, and Policies.* Oxford, UK: Oxford University Press for the Stockholm International Peace Research Institute, 1997; for the official breakdown of the U.S. plutonium stockpile, see *Plutonium: The First 50 Years,* Washington DC: U.S. Department of Energy, February, 1996 (available at http://www.osti.gov/html/osti/opennet/document/pu50yrs/pu50y.html).

[44] Albright, Berkhout, and Walker, *Plutonium and Highly Enriched Uranium 1996*, op. cit. These estimates of Russia's plutonium and HEU stockpiles have substantial uncertainties; note that their sum is over 100 tonnes less than the official estimate of the total in *MPC&A Strategic Plan*, op. cit. Russian statements are generally consistent with the Albright, Walker, and Berkhout estimates on plutonium, but some Russian statements suggest that the HEU figure may be even higher. In a statement in April, 1996, Russian President Boris Yeltsin indicated that the 50 tonnes of weapons plutonium to be placed at Mayak represented 40 percent of the Russian stockpile of weapons plutonium (quoted in Dirk Schiefer and Thomas Shea, "IAEA Perspectives on Excess Materials," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999), suggesting a total military stockpile in the range of 125 tonnes, along with a civilian stockpile officially declared to be just over 30 tonnes, for a total in the range of 155. On HEU, in 1993 then-Minister of Atomic Energy Victor Mikhailov told Elizabeth Martin that the 500 tonnes of HEU covered in the U.S.-Russian HEU purchase agreement represented some 40 percent of the Russian HEU stockpile, suggesting that the total stockpile might be as large as 1250 tonnes, 200 tonnes more than estimated by Albright, Berkhout, and Walker. (See Martin, "A Conversation With Victor Mikhailov," *NUKEM Market Report*, October 1993.) A substantial part of this apparent difference, however, may arise from the Albright, Berkhout, and Walker estimates being based on the number of tonnes of equivalent 90% enriched material, which is smaller than the number of actual tonnes of less enriched material that exists.

stockpile already in storage there[45]—again, not because there is any need for this plutonium, but because the contracts for this work from foreign countries with Soviet-designed reactors keep nuclear workers gainfully employed. (A new DOE initiative to put in place a moratorium on this reprocessing is described in the next section.)

Finally, there is the problem of what to do with the enormous excess stockpiles of plutonium and HEU in the long run. With HEU, the answer in general terms is straightforward (though implementation has been anything but): it can be blended with other forms of uranium to produce non-weapons-usable low enriched uranium, which is a valuable commercial product as fuel for nuclear power reactors. Plutonium can also be blended with uranium to produce fuel, but because of the special handling procedures required by plutonium's radiotoxicity and proliferation hazard, doing so is more expensive than simply buying equivalent low-enriched uranium fuel on the open market, even if the plutonium itself is considered "free." Moreover, in contrast to the situation with uranium, simply blending the plutonium does not solve the proliferation problem, as uranium can be chemically separated from the uranium without great difficulty, at least virtually all mixes of plutonium isotopes are weapons-usable, and plutonium mixed with until it has been irradiated in a reactor.[46]

In short, the problems with management of nuclear material in the former Soviet Union that pose threats to U.S. security boil down to five categories: the materials are insecure; their custodians are on the edge of desperation, in a complex far too large to be sustainable; their management remains shrouded in secrecy; more weapons-usable material continues to be produced; and no sustainable plan is yet in place for getting rid of the enormous stockpiles of weapons-usable material that are no longer needed. In each of these areas, there are U.S. cooperative programs in place to address the problem, which are making some progress—but in each of these areas far more urgently needs to be done.

[45] From the end of July 1996 to the end of December 1998, for example, a period of two and a half years, the amount of separated civil plutonium Russia declared as being either in storage at reprocessing plants or in fabricated fuel increased by 2.1 tonnes, from 27.3 tonnes to 29.4 tonnes. See "Communication Received from Certain Member States Concerning Their Policies Regarding the Management of Plutonium," INFCIRC/549/Add.9, International Atomic Energy Agency, November 11, 1998, and INFCIRC/549/Add.9/1, International Atomic Energy Agency, May 31, 1999 (both available at http://www.iaea.org/worldatom/infcircs/inf501-600.html).

[46] Reactor-grade plutonium can be used to make nuclear weapons at all levels of sophistication. The most detailed unclassified official discussion of the usability of reactor-grade plutonium in weapons is in *Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives,* Washington DC: Department of Energy, DOE-NN-007, January 1997, pp. 37–39. This document also provides descriptions of the proliferation hazards posed by the various steps involved in different approaches to long-term plutonium disposition.

III. THE CURRENT RESPONSE

The United States has two fundamental goals in cooperative programs related to the control of nuclear warheads and fissile material: to reduce the risk of nuclear proliferation, and to achieve deep, transparent, and irreversible nuclear arms reductions. The myriad U.S. programs designed to take steps toward these goals can be divided into five categories corresponding to the five problems just described:

- preventing theft and smuggling of nuclear weapons and material;
- stabilizing the custodians of these stockpiles, providing alternative employment for those no longer needed, and shrinking the nuclear complexes;
- monitoring stockpiles and reductions;
- ending further production of fissile material;
- reducing stockpiles of fissile material.

The programs in each of these areas are making significant progress and deserve strong support; they are among the most cost-effective investments in U.S. security found anywhere in the U.S. budget. (Annual spending on these efforts represents less than one quarter of one percent of the U.S. defense budget.) The U.S. and former Soviet experts working on these programs have managed to make enormous strides, often under extraordinarily difficult circumstances. If judged against the limited goals that many of these programs initially set for themselves, much of the job is already done or well underway. But if judged instead by comparison to what is needed to address the threat, it is clear that current efforts represent only a small beginning.

This basic dichotomy is outlined in Figure 1. Figure 1 shows the categories of effort, capsule descriptions of the limited goals initially set in each category and the more ambitious goals needed to address the threat, and rough percentage estimates of how much of the work needed to accomplish both the initial limited goals and the ultimate goals is now underway. These percentages are purely judgmental; they do *not* describe the fraction of the work already completed, but rather the larger fraction of the work that is at least planned, and covered by budget plans in place for the next few years and international agreements either already negotiated or well underway.

As can be seen from the figure, in most cases 80-90% of the work needed to achieve the initial, limited goals set for these programs is underway. Much of that work will be accomplished in the next few years. But in most cases what is now underway represents only 5-20% of what would be needed to provide real solutions to the security threats the United States faces from these nuclear materials in the former Soviet Union. (The exception is the area that ought in principle to be relatively simple—verifiably stopping the production of still more weapons-usable fissile material—where a substantial fraction of what would ultimately be needed is at least included in proposed budget plans and negotiations.) The remainder of this section will describe in some detail the programs underway in each of these five areas, the progress they have made, and what remains to be done—providing the background for each of the percentage judgments in Figure 1.

Figure 1: Control of Fissile Material: How Much Are We Doing So Far?

Category	Objective (Past vs. Ideal)	Percent Underway (Notional)
Preventing Theft and Smuggling	**Install modern security and accounting systems**	**80%**
	Achieve effective and sustainable security	**20%**
Stabilizing Nuclear Custodians	**Provide short-term jobs for top weapons scientists**	**80%**
	Achieve sustainable economics in a smaller nuclear complex	**10%**
Monitoring Reductions	**Achieve transparency for HEU deal and Mayak storage facility**	**80%**
	Provide wide-ranging transparency base needed for deep reductions	**5%**
Ending Further Production	**Convert or shut down plutonium production reactors**	**90%**
	Verifiably end all HEU and separated Pu production	**50%**
Reducing Stockpiles	**Gain implementable agreement on 34 tonnes of Pu, fix 500-tonne HEU deal**	**60%**
	Reduce Pu, HEU to levels needed to support deep-cuts stockpiles	**10%**

In his State of the Union address in January 1999, President Clinton announced an Expanded Threat Reduction Initiative (ETRI), ostensibly focused on dealing with safeguards for nuclear materials as a key priority. The reality, however, is that with respect to programs for safeguarding nuclear materials, ETRI simply maintained flat funding for existing programs, canceling previously planned cutbacks, with no substantial increases or new initiatives. While a useful step, therefore, ETRI is not the answer: even if all the programs envisioned under the ETRI effort received full funding, much more would remain to be done (see “The Expanded Threat Reduction Initiative,” p. 62). The $100 million increment to ETRI announced in February 2000 as a “Long-Term Nonproliferation Program for Russia,” while deserving strong support, also represents only a fraction of what needs to be done to cooperate with the states of the former Soviet Union to secure, monitor, and reduce nuclear stockpiles (see "DOE's Proposed Long-Term Nonproliferation Program for Russia," p. 70).

Preventing Theft and Smuggling

A "mantrap" installed as part of U.S.-Russian cooperation at the Kurchatov Institute in Moscow, which allows in only authorized workers with appropriate magnetized identification cards and personal code numbers, and detects any attempt to bring weapons in or nuclear material out of the facility. Hundreds of tonnes of nuclear material in Russia is still in buildings not equipped with detectors at the doors that would reliably detect individuals carrying plutonium or HEU out the door. Source: DOE

A variety of programs are in place to directly improve security and accounting for nuclear weapons and materials in the former Soviet Union, and to interdict nuclear smuggling. The United States has (a) a cooperative material protection, control, and accounting (MPC&A) program designed to improve security and accounting for nuclear material in the former Soviet Union, funded by the Department of Energy (DOE); (b) a program to build a secure storage facility for fissile material from dismantled weapons at Mayak, funded by the Department of Defense (DOD); (c) an effort to provide equipment for improving security of nuclear weapon storage and transport, also funded by DOD; (d) programs that have removed weapons-usable nuclear material from selected particularly vulnerable sites; and (e) several programs in Defense, Energy, Customs, and the Federal Bureau of Investigation to cooperate with relevant countries in improving capabilities to stop nuclear smuggling. Other countries have modest cooperative programs contributing to MPC&A (particularly in the non-Russian states of the former Soviet Union), nuclear smuggling interdiction, and (in the case of Japan) containers for the Mayak storage facility.

MPC&A

The MPC&A program has made substantial progress in recent years, but has an enormously long road yet to travel.[1] There are now agreements in place to cooperate at

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[1] For official summaries of the MPC&A program, see *MPC&A Program Strategic Plan*, op. cit.; and Kenneth B. Sheely and Mary Alice Hayward, "New Strategic Directions in the MPC&A Program," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999 (available at http://www.dp.doe.gov/nn/mpca/pubs/frame_tec.htm). For other recent summaries, see Oleg Bukharin, Matthew Bunn, and Kenneth N. Luongo, *Renewing the Partnership: Recommendations for Accelerated Action to Secure Nuclear Material in the Former Soviet Union,* (Washington DC: Russian-American Nuclear Security Advisory Council, forthcoming); *Protecting Nuclear Material In Russia*, op. cit.; William C. Potter and Fred L. Wehling, "Sustainable Nuclear Material Security in Russia: Commitment, Consolidation, and Culture," presentation to the American Association for the Advancement of Slavic Studies, 31st National Convention, St. Louis, MO, November 18-21, 1999;

virtually every facility in the former Soviet Union where HEU or plutonium outside of weapons is located. A new government-to-government umbrella agreement governing the program was reached between the United States and Russia on October 2, 1999.[2] The United States had allocated $573 million to this cooperation through March 1999, with the program budget at $150 million in fiscal year (FY) 2000, and $172 million more requested for FY2001 (see "DOE's Proposed Long-Term Nonproliferation Initiative for Russia," p. 70).[3] Hundreds of U.S. and Russian experts are at work designing and installing improved MPC&A systems. As of May 1999, security and accounting system upgrades had been declared completed at all of the nine sites in the non-Russian states of the former Soviet Union where separated plutonium or HEU is still located, along with 11 sites in Russia.[4] Security and accounting equipment upgrades for 50 tonnes of weapons-usable material were expected to be completed by the end of 1999, with an additional 50 tonnes to be added by the end of 2000.[5] Particularly remarkable progress is being made in working with the Russian Navy to secure HEU naval fuel.[6]

The MPC&A program is also undertaking a variety of efforts that go well beyond equipment upgrades at individual sites. First, the program is sponsoring a substantial set of initiatives to train MPC&A operators, managers, and regulators.[7] The program has

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Emily Ewell Daughtry and Fred Wehling, "Cooperative Efforts to Secure Fissile Material in the NIS: Shortcomings, Successes, and Recommendations for the Future," *Nonproliferation Review*, forthcoming; National Research Council, Committee on Dual Use Technologies Export Control and Materials Protection Control and Accountability, *Proliferation Concerns: Assessing U.S. Efforts to Help Contain Nuclear and Other Dangerous Materials and Technologies in the Former Soviet Union,* Washington DC: National Academy Press, 1997; James Doyle, "Improving Nuclear Materials Security in the Former Soviet Union: Next Steps for the MPC&A Program," *Arms Control Today*, March 1998; Bunn and Holdren, "Managing Military Uranium and Plutonium," op. cit.; and Perry, "Securing Russian Materials," op. cit.

[2] A press release on this event, and the text of the agreement itself, can be found at http://www.dp.doe.gov/nn/mpca/frame04.htm, and http://www.dp.doe.gov/nn/mpca/frame05.htm, respectively.

[3] For the total, see *Fact Sheet: U.S. Commitment to the Treaty on the Non-Proliferation of Nuclear Weapons*, Washington DC: U.S. Department of State, Bureau of Nonproliferation, May 3, 1999; for the FY2000 and FY2001 figures, see *FY2001 DOE Budget Request to Congress*, U.S. Department of Energy, February 7, 2000 (available at http://www.cfo.doe.gov/budget/01budget/index.htm); the FY2001 request includes $150 million in the core MPC&A program, and $20 million more for MPC&A efforts at Mayak and the Russian Navy, and for MPC&A consolidation, in a $100 million proposed "Long-Term Nonproliferation Program for Russia." See *Fact Sheet: Long-Term Nonproliferation Program for Russia,* U.S. Department of Energy, February 7, 2000.

[4] *Significant Milestones in Securing and Controlling Nuclear Materials*, Washington DC: Department of Energy, May 1999.

[5] Rose Gottemoeller, Assistant Secretary for Nonproliferation and National Security, Department of Energy, "The Importance of Sustainability in Securing Nuclear Material in the Former Soviet Union," paper presented at "Global '99: Nuclear Technology— Bridging the Millenia," Jackson Hole, Wyoming, 30 August-2 September 1999 (available at http://www.dp.doe.gov/nn/mpca/pubs/frame_tec.htm).

[6] See Adm. Nikolai Yurasov, "Modernization of Navy Nuclear Fuel Storage Protection," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999, and James Clay Moltz, "Assessing U.S. Assistance Program for Submarine Dismantlement and the Naval Fuel Cycle," forthcoming in *Nonproliferation Review.*

[7] For a useful discussion of MPC&A training programs, see Todd Perry, "Coordinating U.S.-Sponsored MPC&A Training: A Prerequisite for Sustainable Russian MPC&A Upgrades," in *Proceedings of Global '99: Nuclear Technology- Bridging the Millenia*, Jackson Hole, Wyoming, 30 August-2 September 1999, La Grange Park, IL: American Nuclear Society, 1999.

also undertaken efforts to improve the national-level MPC&A systems in Russia and other former Soviet states, including establishing computerized national nuclear material inventory systems, upgrading the security of fissile material transportation, and helping the former Soviet states establish effective MPC&A regulatory programs—a particularly critical factor if site managers are to be given the necessary incentives to put resources toward effective MPC&A.[8]

Recently, realizing the enormous size of the job of ensuring effective security and accounting at all of the nearly 400 buildings where nuclear material is now located, the United States and Russia have launched new efforts to consolidate material at fewer buildings within sites, and to remove material from some sites entirely. Within the Russian Navy, for example, the number of sites with fresh HEU fuel has been reduced from 20 to three; at the Luch Production Association near Moscow, the number of buildings containing HEU has been reduced from 30 to five. Under the new consolidation initiative, the United States will pay Russia to bring HEU from potentially vulnerable facilities to Luch or Dmitrovgrad to be blended to non-weapons-usable 19% enriched LEU, which can then be stored or further blended and sold. A pilot project has been agreed to under which at least one site would have all of its HEU completely removed each year for several years, and several tonnes of HEU would be blended to LEU over that period.[9]

Finally, after providing emergency assistance—from food and warm uniforms for guards to backup electricity supplies—in the aftermath of the August 1998 financial crisis, the program has undertaken a new focus on "sustainability" of upgrades over the long term—focusing so far on making sure that equipment installed with U.S. assistance can be maintained.[10] Indeed, the mission statement of the program has been changed to include consolidation and sustainability as fundamental goals of the effort.

Overall, the progress in MPC&A has been substantial enough to have spillover benefits in other areas: for example, the director of one of the facilities in Russia where deadly biological pathogens are stored was concerned about the possibility that some of

[8] For a summary of the U.S. efforts at regulatory support, see Fredric Morris et al., "Creating the Regulatory Base for MPC&A in the Russian Federation: Challenges and Strategy," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999.
[9] For discussions of the material consolidation efforts, see Gottemoeller, "The Importance of Sustainability," op. cit., and Thomas Wander and Neil R. Zack, "The MPC&A Material Consolidation and Conversion Project: Exploring the Material Conversion Option," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999. For a brief description of the pilot project, see "Significant Milestones Reached for the MPC&A Program's Material Consolidation and Conversion Project," September/October 1999 MPC&A News, available at http://www.dp.doe.gov/nn/mpca/frame04.htm.
[10] For official summaries of the sustainability effort, see Gottemoeller, "The Importance of Sustainability," op. cit.; Carrie Smarto et al., "MPC&A Site Operations and Sustainability: A Policy Overview," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999 (available at http://www.dp.doe.gov/nn/mpca/pubs/frame_tec.htm); and Michael Haase et. al., "Material Protection, Control, and Accountancy (MPC&A) Sustainability," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999. For unofficial reviews of the issue, see Potter and Wehling, "Sustainable Nuclear Material Security," op. cit.; Bukharin, Bunn, and Luongo, *Renewing the Partnership*, op. cit.; and Todd Perry, "From Triage to Long-Term Care: A U.S. NGO Perspective on the Future of the MPC&A Program," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999.

these materials might be stolen, had heard about the cooperative work to improve security for nuclear materials at Chelyabinsk-70, which was near his facility, and proposed a cooperative security upgrade plan to the United States based on the MPC&A work down the road.[11]

Nuclear material accounting equipment, provided with U.S. assistance. Many facilities in the former Soviet Union do not have accurate, measured inventories of the material on hand, and do not have reliable means of detecting whether material has been tampered with, making it difficult to know if material has been stolen. Material accounting is moving more slowly than other parts of the MPC&A program. Source: DOE

Despite this record, the vast majority of the work required remains to be done. The 100 tonnes of nuclear material expected to be housed in facilities with fully upgraded MPC&A systems by the end of 2000 represents only one-sixth of the non-weapons fissile material in the former Soviet Union. While progress has been made at a wide range of other facilities that are not yet close to completion, most fissile material in the former Soviet Union is housed in buildings whose security and accounting systems have not yet been substantially upgraded. There are still some sensitive facilities with very large quantities of fissile material where Russia has been unwilling to grant any access to at all (such as the nuclear weapons assembly/disassembly facilities and the HEU fuel fabrication line at Elektrostal), and as a result, no cooperative upgrades at these facilities have been accomplished, and in late 1999 the U.S. MPC&A management team put a hold on further efforts at those sites.

While equipment for material accounting is being provided, efforts to conduct real inventories are languishing.[12] Only modest progress has been made in putting in place effective MPC&A regulation, with the teeth to fine or shut down facilities that fail to meet standards—without which facility managers have little incentive to devote resources from tight budgets to ensuring adequate safeguards and security. Most significantly, the former Soviet economies are only beginning uneven recoveries from their deep depressions, and the challenge of ensuring sustainable security after the period of initial upgrading is completed remains a fundamental one. Today, there are facilities in the former Soviet Union where some U.S.-provided equipment is simply not being used, as

[11] Remarks by Anne Harrington, Senior Coordinator for Nonproliferation/Science Cooperation, U.S. Department of State, at the conference on "Assessing U.S. Dismantlement and Nonproliferation Assistance Programs in the Newly Independent States," Center for Nonproliferation Studies, Monterey Institute of International Studies, Monterey, California, December 11-13, 1999.

[12] See, for example, Potter at the 1999 Carnegie International Nonproliferation Conference, op. cit.; see also David D. Wilkey and Charles R. Hatcher, "Implementation of Materials Accounting in Russia," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999.

the facilities do not have the money to operate and maintain it, or the incentive to use what little money they have for that purpose. While the MPC&A program's initial work on improving the sustainability of MPC&A upgrades is laudable, much more remains to be done: the challenge of fostering change in Soviet-era thinking and habits is a difficult one, particularly in an environment in which the former Soviet participants face a wide range of other urgent problems, some as basic as providing the necessities of life for themselves and their families.

It is now clear that the MPC&A job will be larger and more challenging than originally anticipated—as the Administration acknowledged in its ETRI proposals. Early planning envisioned that initial upgrades would be completed by 2002, that by this time the economies of the former Soviet states would have improved, and that therefore maintenance and further improvement of the installed systems could be handed off to them with only modest needs for further U.S. assistance. The total U.S. program cost envisioned was less than a billion dollars. Since those plans were made, expanding U.S.-Russian cooperation has expanded the U.S. understanding of the scope of the work to be done: it has become clear that there are significantly more buildings containing fissile material than had been envisioned, that the scope of required upgrades is even larger than had been thought, and that the need for continued funding for sustainability is much greater than had been envisioned.[13] At current funding levels, it is now expected to be more than a decade before even initial MPC&A upgrades are completed for all the HEU and plutonium in the former Soviet Union—a program pace that simply does not correspond to the urgency of the threat.

Moreover, political and management issues in both Russia and the United States continue to pose significant obstacles to MPC&A progress. As noted above, Russian restrictions on access to facilities (and U.S. reactions to them) have slowed progress at a number of facilities. Worse, virtually all levels of the Russian system, from the President to managers of individual areas handling nuclear material, have generally placed low priority on improving safeguards and security when allocating their financial and personnel resources (though there are some modest signs of improvement in this respect at MINATOM, which has recently developed its own plan for MPC&A upgrades throughout its complex).[14] At the same time, Russia has attempted to impose taxes on the U.S. assistance, which reduces both the amount of the assistance available for its intended purpose and the political support for the assistance in the United States. In the United States, the President, Vice President, the National Security Advisor, and Cabinet secretaries have given only sporadic attention to this issue, have allowed problems at the working level to fester, and have only rarely put security for nuclear material on the top of the security agenda with Russia where it belongs. A prolonged period of interagency disputes over how to implement the program was followed—after full budget and program responsibility was shouldered by DOE in FY1996—by an equally prolonged period of pulling and hauling between different factions with different approaches at DOE headquarters and the DOE laboratories.

From a Russian perspective, these internal U.S. disputes have resulted in frequent and seemingly arbitrary changes in both the U.S. personnel managing activities at

[13] See discussion in National Research Council, *Protecting Nuclear Material in Russia*, op. cit.
[14] Interviews with Russian officials, October, 1999.

particular sites, and the approaches being taken.[15] Only the most modest efforts have been made to coordinate the MPC&A program with the many other fissile material-related efforts described in this report. The personnel resources devoted to the effort have been so slim that many of those involved are suffering from exhaustion and burn-out, and have no time to work seriously on envisioning and implementing new approaches.

A secure storage facility for plutonium and HEU from dismantled weapons under construction at Mayak, financed by the U.S. Cooperative Threat Reduction program. The facility will provide a highly secure storage site, and is expected to be placed under international monitoring—but unless additional modules are built, it will not have the capacity to store all the material from Russia's dismantled warheads, and U.S.-Russian discussions of transparency for the facility have not yet reached agreement. Source: DOD

MAYAK STORAGE FACILITY

In parallel with the MPC&A program, which is largely designed to improve security for fissile material at the facilities where it has been located, the U.S. Department of Defense has been helping Russia design and build a new secure storage facility for plutonium and HEU from dismantled weapons, at Ozersk (formerly Chelyabinsk-65).[16] Russian officials had stressed in the early 1990s that the limited capacity of the available storage space for this material could pose a major stumbling block to continued warhead dismantlement, and that the locations where this material was then being stored did not meet modern safety and security requirements.[17] After years of delays, the first module of the facility, capable of holding 25,000 fissile material containers (the result of the dismantlement of about 8,000 warheads, as each warhead results in 3–4 containers of fissile material), is now coming along well, and is expected to open in 2002. (The United States and Japan are also supplying the containers.) Originally, the facility was planned to have two modules, for a total of 50,000 containers, and indeed, a second facility of equal size was to be built at another site, to accommodate all the excess fissile material from dismantled Russian weapons. Costs have been rising

[15] A prominent example is the issue of access: after U.S. teams negotiated and agreed on arrangements for ensuring that U.S.-provided equipment was used appropriately at sites where the Russian side indicated it would not be possible to grant access to U.S. personnel, in the fall of 1999 the U.S. side turned around and rejected the agreed procedures, demanded direct access by U.S. personnel, and cut off further work at the relevant sites until such access was granted. (Interviews with U.S. and Russian participants.)

[16] Some of the background of this facility is summarized in U.S. General Accounting Office, *Weapons of Mass Destruction: Effort to Reduce Russian Arsenals May Cost More, Achieve Less Than Planned*, Washington DC: U.S. General Accounting Office, GAO/NSIAD-99-76, April 1999.

[17] For an account of storage of fissile material from dismantled weapons at Tomsk-7, calling attention to remarkable security deficiencies there, see Alexander Bolsunovsky and Valery Meshchikov, "Nuclear Security is Inadequate and Outdated," *Moscow News*, No. 49 (December 9-15, 1994).

as delays continue, however, and while the construction cost was once to have been split 50/50 between Russia and the United States, Russia has indicated that it will not be able to pay its half; as a result, the Defense Department has deferred anything beyond the first module of the first facility for now. If a decision is made to proceed with the second module, it could be completed by 2006.

This first wing will not be sufficient even to hold the material from all the weapons Russia has already dismantled, let alone material from additional dismantlement. Moreover, unless the Congressional requirement that this facility hold only material from dismantled warheads is modified in the future, it will not be possible to use the Mayak building as a secure place to consolidate vulnerable stockpiles of fissile material from elsewhere in the former Soviet Union (even if additional capacity for that purpose were eventually made available at Mayak). While it was originally envisioned that the material stored in Mayak would be in the form of metal plutonium and HEU components from dismantled weapons, in the wake of President Yeltsin's offer to make the facility available for IAEA verification, MINATOM decided to convert all the material to metal slugs no longer identifiable as components before placing them in the facility—even though the United States, Russia, and the IAEA are working to develop means to carry out monitoring of containers holding weapons components without revealing classified information (as described below). The United States and MINATOM are discussing the provision of substantial U.S. assistance for reshaping the plutonium components (or "pits"), packaging the resulting shapes, and shipping them to the Mayak storage facility, but this assistance is contingent on agreement on transparency measures for the process, and as of late 1999 there had been virtually no progress toward that objective. Indeed, for the Mayak project overall, no agreement has yet been reached on the transparency measures the United States has sought, in return for its assistance, to meet Congressional requirements to confirm that (a) the material in the facility comes from dismantled weapons, (b) the material is safe and secure, and (c) the material is not being returned to weapons (see discussion under monitoring, below).[18]

Nuclear Warhead Security

The U.S. DOD and the Russian Ministry of Defense have been cooperating for several years to improve security for nuclear warheads themselves.[19] The cooperation

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[18] The principal transparency difficulty relates to confirming that the material comes from weapons, which is complicated by the fact that the material arriving at the facility will no longer be in the form of weapons components—which would be resolved if the negotiations over transparency for the conversion of the components could be addressed. For further description of the issues, see the discussion of monitoring stockpiles and reductions, below.

[19] For a discussion of this effort, see John Leppingwell and Nikolai Sokov, "Assessment of Delivery Vehicle Elimination and Weapons Protection, Control, and Accounting," *Nonproliferation Review*, forthcoming. A useful earlier description from a Russian perspective can be found in Gen. Evgeniy Maslin (former commander, 12th Main Directorate), "Russian-U.S. Cooperation on Nuclear Weapons Safety," in John M. Shields and William C. Potter, eds., *Dismantling the Cold War: U.S. and NIS Perspectives on the Nunn-Lugar Cooperative Threat Reduction Program*, Cambridge, MA: MIT Press, CSIA Studies in International Security, 1997. More recent brief descriptions of this cooperation can be found in Gen. Igor Valynkin, press conference, February 3, 1999, Official Kremlin International News Broadcast, *Federal Information Systems Corporation*; Gen. Evgeniy Maslin, "The CTR Program and Russia's National

Fifty sets of security fencing such as that shown above are being provided by the Cooperative Threat Reduction program to help upgrade security at Russian nuclear warhead storage sites. Nuclear warheads are believed to be much more secure than fissile material, but even in this sector, low and intermittent pay and increasing reports of crime and poor morale have raised security concerns. Source: DOD

first focused on transportation, with the provision of security upgrade kits for railcars, secure blankets, "supercontainers" for warhead transport and storage, and the like. While that effort continues, efforts are now underway to improve security and accounting of warheads in storage as well, with the provision of computers for creating a real-time accounting system (replacing the paper accounting systems of the past), equipment and training for screening personnel, and improved security equipment for actual warhead sites. A "model" facility has been established at Sergeyev Posad to demonstrate modern equipment, which the United States can then supply at Russian request for installation at actual warhead storage sites. (The United States has also supplied computer software tools for assessing security vulnerabilities at such sites and designing improvements to correct them.) The Sergeyev Posad facility will also serve as a training center for warhead security forces.

While the transportation security program is nearly complete, the storage security program is still in its early stages. "Quick fix" fencing and sensor systems to upgrade outer perimeters is now being procured for 50 storage sites, and more elaborate upgrades including sensors and other equipment for the interior of facilities are planned for the future. Access is still a fundamental issue slowing these upgrades, however: under U.S. Department of Defense rules the United States needs to be able to have some means of confirming that U.S.-supplied equipment is being used for the purposes intended at the facilities intended, while under current Russian rules, the very locations of these storage facilities remain state secrets (despite the fact that General Habiger was allowed to visit a few of them). Resolving this issue so as to allow the upgrades to move forward is likely to require very high-level negotiations.[20]

Removing Material from Vulnerable Sites

In some cases, the United States and its cooperative partners in the former Soviet Union have concluded that it makes more sense to relocate the material to a safer location than to try to protect it in place. In November, 1994, after more than a year of secret discussions and preparation, nearly 600 kilograms of weapons-usable HEU was airlifted

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Security Interests," *Yaderny Kontrol Digest*, Vol. 5, No. 1, Winter 2000; and U.S. Department of Defense, "Secretary Tours Russian Defense Facility, Nuclear Weapons Security Projects Viewed at Sergiev Posad," press release, February 1998.

[20] Briefing by Gen. Thomas Kuenning (ret.), Director Cooperative Threat Reduction, Center for Nonproliferation Studies, Monterey, California, December 13, 1999.

from the Ulba facility at Ust-Kamenogorsk in Kazakhstan to the United States, in what was known as Project Sapphire. The Kazakh government had indicated to the United States that the material could not be adequately protected at Ulba, and there were indications that Iranian representatives had expressed interest in the material. The United States paid for the operation, and in effect purchased the material from Kazakhstan with both cash and promises of assistance for other projects.[21] After shipment to the United States, the material was blended to non-weapons-usable LEU under IAEA safeguards. Similarly, in 1997, again after more than a year of secret discussions and preparations, several kilograms of HEU—some fresh and some irradiated—were removed from a research facility near Tbilisi, Georgia, and shipped to the British reprocessing plant at Dounreay for processing (with U.S. funding and assistance), in an effort known as Project Auburn Endeavor.[22] Finally, the United States and the Kazakh governments are considering a project to ship irradiated fuel elements from a Kazakh breeder reactor located on the shores of the Caspian Sea across from Iran, which are no longer radioactive enough to provide much of a barrier to theft, and some of which contain "ivory-grade" plutonium (that is, plutonium with an even lower percentage of undesirable isotopes than typical weapons-grade plutonium) to a more secure site deep within Kazakhstan.[23] Although each of these efforts involved relatively modest quantities of material, the intricacies of inter-government negotiation, long-distance shipment, safety assessments and preparations, and the like led to each of them taking months of effort and costing tens of millions of dollars. Moreover, as noted above, a new effort to consolidate material within Russia is being undertaken as part of the MPC&A program—and there have been some Russian expressions of interest in the idea of including not only material within Russia but other material that originated in the Soviet Union as well, with a small amount of DOE funding allocated to that goal in the FY2001 request.[24] As described in Section IV of this report, such efforts can and should be radically expanded and accelerated.

Nuclear Smuggling Interdiction

Once fissile material has been removed from authorized control, much of the battle is already lost—finding stolen fissile material within a country, or detecting and interdicting its passage across borders, are herculean tasks, in most cases only practicable if good intelligence and police work tells officials where to look. Nevertheless, a "second line of defense" designed to help catch nuclear thieves and interdict nuclear smuggling is

[21] For a detailed account, see Potter, "Project Sapphire," op. cit.
[22] See, for example, Michael R. Gordon, "U.S. and Britain Relocate a Cache of Nuclear Fuel," *New York Times*, April 20, 1998, and Toby Dalton, "Tbilisi: The Tip of the Nuclear Iceberg," Carnegie Endowment for International Peace, Issue Brief No. 1, April 23, 1998 (available at http://www.ceip.org/nnp).
[23] See, for example, Steve Goldstein, "U.S. Plots Move of Plutonium From Risky Site Near Iran," *Philadelphia Inquirer,* September 6, 1998; after the Goldstein story was written, the projected cost of the move increased, and assessments of the security of the fuel at its existing site became more optimistic. Hence, in December 1999, the U.S. and Kazakh governments agreed simply to continue studying various options for longer-term storage of this material, rather than moving it immediately. See "U.S., Kazakhstan Agree to Decommission, Secure Kazakhstani Nuclear Reactor Near Iranian Border," Department of Energy press release, December 21, 1999.
[24] *Fact Sheet: Long-Term Nonproliferation Program for Russia,* op. cit.

an important part of the overall effort, especially as visibly increasing the apparent likelihood of being caught may offer some deterrent effect against smuggling. Limited efforts are being pursued by the United States and other countries to exchange intelligence, coordinate responses, and train and equip police, intelligence forces, customs agencies, and border guards in the relevant states.[25]

A "Programme for Preventing and Combatting Illicit Trafficking in Nuclear Material" agreed at the P-8 Nuclear Safety and Security Summit in Moscow in April 1996 has made slow progress to date. It has focused primarily on developing information exchange mechanisms (still a difficult issue where sensitive police, intelligence, or military nuclear information is involved), expanding the number of countries involved, and a series of conferences and development activities related to "nuclear forensics"—means to help determine the origin of a seized sample of nuclear material. Many of the international efforts to exchange information and consult on possible responses in these areas are now being coordinated by the IAEA.[26]

A variety of U.S. agencies have been providing specific training and equipment to relevant states to deal with nuclear smuggling. With funding from DOD, the U.S. Customs Service has provided training and equipment to customs and border officials in key states outside of Russia. Similarly, also with DOD funding, the FBI has been working to provide training to police and other officials in relevant countries, generally at the International Law Enforcement Academy in Budapest, but increasingly in-country as well. Between them, these programs are planned to receive $17 million over fiscal 2000-2004.[27] The Department of Energy has launched a "Second Line of Defense" effort focused on customs and border posts within Russia itself, which has installed nuclear material detectors at three key border transit points (including Moscow's Sheremetyevo airport and two points at Astrakhan on the Caspian Sea). Working closely with the Russian State Customs Committee, the Second Line of Defense program has identified 22 high-priority transit points for installation of equipment. The Russian customs officials have been highly motivated to participate and to sustain the equipment because it brings in revenue by detecting various other types of isotopes on which insufficient duties have been paid. The program was funded at $3 million dollars in FY2000, and $3 million more is planned for FY2001 (from the State Department's Nonproliferation and Disarmament Fund). With only a few million in additional funding, equipment could be rapidly installed at all of the critical transit points identified—and much the same could be done for the states outside of Russia as well.[28] Some of these programs provide

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[25] For a recent summary of the U.S. part of this effort, see Scott Parrish and Tamara Robinson, "An Assessment of U.S. Nonproliferation Assistance to the NIS: Export Controls, Illicit Trafficking, and Braindrain," *Nonproliferation Review,* forthcoming. For summaries of DOE's efforts, see Lara Cantuti and Lee Thomas, "The Second Line of Defense Program," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999, and *Countering the Threat: DOE's Nuclear Smuggling Program Plan*, Washington DC: Department of Energy, March 1997.

[26] For an official summary of the IAEA's activities in this area, see "Measures Against Illicit Trafficking in Nuclear Materials and Other Radioactive Sources," report to the IAEA General Conference, GC(43)/13, Vienna, Austria: IAEA, August 30, 1999 (available at http://www.iaea.or.at/GC/gc43/documents/gc43-13.html).

[27] *Expanded Threat Reduction Initiative,* op. cit.

[28] Interview with DOE official.

equipment and training explicitly intended to address the widespread problem of corruption among border patrol and customs forces—for example equipment for detecting nuclear material that is equipped with video cameras that send an image of the transactions that take place to another location less readily accessible for a bribe.

Several departments—particularly State, but also Commerce and Energy, among others—also have programs designed to strengthen export controls and border security more generally, which provide an important foundation for nuclear smuggling interdiction efforts.[29] To date, however, U.S. programs focused on interdicting nuclear smuggling have been piecemeal and have not yet gelled into a comprehensive plan.

In short, as suggested in Figure 1, if one judges the MPC&A program and other efforts to prevent theft and smuggling of nuclear material by the limited goal of providing initial hardware upgrades and associated training, then the programs are well on their way, and perhaps 80 percent or more of the job is covered by plans, budgets, and agreements already in place. But if the goal is to achieve effective and sustainable security for all the weapons-usable nuclear material in the former Soviet Union, what is now underway represents something closer to 20% of what is needed. Achieving that objective within a few years would require a dramatic increase in both financial and personnel resources and political leadership devoted to the problem. The shape of such an expanded and accelerated program is outlined in Section IV of this report.

A commercial diamond-cutting line (financed by a South Korean firm) is among the civilian enterprises employing former nuclear weapons workers in Sarov, home of Russia's largest nuclear weapons laboratory.
Source: Los Alamos

Stabilizing Nuclear Custodians

As essential as efforts to improve security systems for warheads and materials are, they will not solve the proliferation problem if the people who guard and manage nuclear weapons and materials are desperate, ill-paid, underfed, unable to provide for their families, and embedded in a larger culture of crime and corruption. To address the desperation that could lead to theft of nuclear material or sale of nuclear knowledge, it is critical to (a) help Russia reduce the size of its nuclear complex (both military and civilian) to a level it

[29] In the State Department's Freedom Support Act funds, there is a substantial program on export control and border security for the newly independent states, funded at $40 million in FY2000. Similarly, in State's Nonproliferation, Anti-Terrorism, De-mining and Related (NADR) account, there is an export control support program—which also pays for some detection equipment related to nuclear smuggling—which was funded at $10 million in FY2000 (for activities worldwide, not just in the former Soviet Union). And as noted in the text, some funding from State's Nonproliferation and Disarmament Fund goes to support activities to counter nuclear smuggling, including programs administered by the State Department and by others.

can afford to maintain safely and securely, including helping to provide alternative employment for the excess nuclear scientists and workers, and (b) work with Russia to ensure that the scientists, workers, and guards who remain as custodians of nuclear weapons, materials, and information are adequately paid, fed, and housed. The second of these objectives is largely something Russia will have to do for itself; taxpayers from other countries cannot be expected to pay for the maintenance of a nuclear stockpile aimed at them. But that makes it all the more essential to help Russia shrink its complex to a size Russia can sustain on its own, appropriate to the complex's post-Cold War missions—which is every bit as much in Russia's interest as it is in the U.S. interest. From the U.S. point of view, shrinking the Russian weapons complex is also essential to reduce Russia's currently huge capability to fabricate new nuclear weapons, should circumstances change. Moreover, such programs can harness the considerable technical skills of Russia's nuclear scientists both to Russia's economic recovery and to providing useful scientific and technological input to U.S. programs. Several U.S. and international programs are underway which focus on different aspects of these issues.

The HEU Purchase Agreement and Commercial Deals

Large-scale commercial and quasi-commercial deals are currently the largest sources of hard currency available to stabilize the giant Russian nuclear complex. The U.S.-Russian HEU Purchase Agreement (described below), in which the United States is buying low-enriched uranium (LEU) blended from HEU from dismantled Russian nuclear weapons, provides hundreds of millions of dollars a year—the income for most of the remaining workers at several of Russia's largest nuclear weapons complex sites. Similarly, several Russian nuclear sites have commercial contracts providing enrichment, reprocessing, or fuel fabrication services to foreign customers, which provide larger income streams than foreign assistance programs generally do. Few attempts have been made, however, to tie any of these contracts or agreements to conversion efforts or nuclear security improvements.

Science and Technology Cooperation Programs

The International Science and Technology Center (ISTC) in Moscow, the similar center in Kiev, and a variety of lab-to-lab programs are already employing thousands of former Soviet weapons scientists in useful civilian work.[30] As its name implies, the ISTC

[30] For a discussion of U.S. programs intended to employ former weapons scientists in general, see Parrish and Robinson, "An Assessment of U.S. Nonproliferation Assistance to the NIS," op. cit.; for the nuclear portion considered in this paper, see also Sharon Weiner, *Nuclear Cities News*, Vol. 1, Princeton, NJ: Princeton University Center for Energy and Environmental Studies and Russian-American Nuclear Security Advisory Council, December 1999 (available at www.princeton.edu/~ransac). For information on the ISTC in particular, see the Center's web site (www.istc.ru) and the website for the similar center in Ukraine (www.stcu.kiev.ua). See also National Research Council, Committee to Assess the International Science and Technology Center, *An Assessment of the International Science and Technology Center: Redirecting Expertise in Weapons of Mass Destruction in the Former Soviet Union,* Washington DC: National Academy Press, 1996; Glenn E. Schweitzer (first director of the Moscow ISTC), *Moscow DMZ: The Story*

is a broad international effort, with funding from the United States, the European Union, Japan, and other countries, and staff drawn from both donor and recipient states. The ISTC has provided grants to some 24,000 former weapons scientists (many of them for only a small fraction of their time, however), for 835 projects, with international funding of $231 million—$92.8 million of which was from the United States.[31] Of these, Russia's nuclear cities accounted for 280 projects funded at roughly $39 million.[32] After allocating $59 million to the U.S. contribution to the ISTC and its sister center in Ukraine in FY2000, the Administration is requesting a further $45 million in FY2001.[33]

In recent years, in addition to its core mission of providing grants for research, the ISTC has been financing training programs in key aspects of commercializing technology (ranging from protecting intellectual property rights in technological innovations to drawing up business plans), and, though a new "ISTC Partners" program, seeking to draw in private firms interested in funding R&D by former weapons scientists through the ISTC mechanism. Recently, for example, Mobil Oil agreed to fund researchers from Sarov (formerly Arzamas-16, one of Russia's two main weapons design laboratories) to do mathematical modeling of oil flow in porous media.[34]

Similarly, DOE's Initiatives for Proliferation Prevention program (IPP, formerly the Industrial Partnering Program), which seeks to provide initial funds to link Russian and U.S. laboratory technical experts with businesses willing to invest in commercializing their technologies, is also providing temporary employment for thousands of former weapons scientists, and attempting to partner Russian institutes with U.S. labs and industry to bring promising technologies to market.[35] The concept has been to begin with basic R&D involving only Russian and U.S. labs ("Thrust I" projects), then bring in U.S. industry on a cost-shared basis as the projects progressed toward commercialization ("Thrust II"), and finally to have industry pay the entire cost of the final phase, when the projects became ready for commercialization ("Thrust III"). As of November 1999, IPP had allocated $106 million to fund 456 projects in the former Soviet states; of these, 81 projects, with proposed funding of $21 million, were in Russia's closed nuclear cities. IPP's budget in FY2000 was $22.5 million, and a further $22.5 million is requested for FY2001. So far, however, only a few IPP projects have graduated to being commercially self-supporting, much of the money has historically gone to fund the U.S. laboratory participation, and some of the remainder has historically gone to Russian taxes and overhead (from which the ISTC funds are exempted). Nevertheless, a

of the International Effort to Convert Russian Weapons Science to Peaceful Purposes, Armonk, NY: M.E. Sharpe, 1996; Victor Alessi and Ronald F. Lehman II, "Science in the Pursuit of Peace: The Success and Future of the ISTC," *Arms Control Today*, June/July 1998; and R. Adam Moody, "The International Science Center Initiative," in Potter and Shields, *Dismantling the Cold War*, op. cit.

31 Data from the ISTC web page, January, 2000.

32 Weiner, *Nuclear Cities News*, op. cit.

33 *International Affairs (Function 150) Fiscal Year 2001 Budget Request: Summary and Highlights of Accounts by Appropriations Subcommittees*, U.S. Department of State, February 7, 2000 (available at http://www.state.gov/www/budget/fy2001/fn150/fn150_fy2001_cmtes.html#forops).

34 Weiner, *Nuclear Cities News,* op. cit.

35 For brief overviews of IPP, see *Program Strategy: Initiatives for Proliferation Prevention*, Washington DC: U.S. Department of Energy, November 1999, and the IPP home page, at http://www-citr.ornl.gov /ippover.html. For data on specific projects, see Weiner, *Nuclear Cities News*, op. cit.

significant number of IPP projects are now nearing the commercialization stage, and DOE has been undertaking substantial reforms.[36]

The United States (as well as George Soros and other sources) has also provided funding to the Civilian Research and Development Foundation (CRDF), a private organization (much smaller than the ISTC) which also provides funding for scientists in the former Soviet Union (who need not be former weapons scientists, in the case of CRDF) to do civilian work. CRDF has a small program focused on the nuclear cities, which helps arrange funding for U.S. collaborators to work with nuclear city researchers on joint R&D projects with commercial potential, and also helps fund joint projects between Russian labs, Russian industry, and U.S. industry.[37]

Nuclear Cities Initiative

Most recently, the United States and Russia have established a joint "Nuclear Cities Initiative" designed to help downsize Russia's nuclear weapons complex and diversify the economic base of the closed cities of that complex, providing alternative employment for scientists and workers no longer needed for nuclear weapons-related activities.[38] This is an enormous undertaking, and so far U.S. funding for this effort is extremely modest: the effort received $15 million in FY1999, but Congress slashed it to $7.5 million in FY2000 (although the Administration had requested $30 million for that fiscal year). The Administration has requested $17.5 million for this effort in FY2001, with another $10 million in associated funds to accelerate the shut-down and conversion to civilian tasks of two of Russia's warhead dismantlement facilities—the small Avangard plant in Sarov, and the plant in Zarechnyy (formerly Penza-19), both of which Russia has announced plans to close (see "DOE's Proposed Long-Term Nonproliferation Initiative for Russia," p. 70).[39] By contrast, DOE has officially estimated that $550 million over 5 years—nearly four times currently planned budgets—would be needed to

[36] For a General Accounting Office review of IPP that was critical on these and other grounds, see General Accounting Office, *Nuclear Nonproliferation: Concerns With DOE's Efforts to Reduce the Risks Posed by Russia's Unemployed Weapons Scientists,* GAO/RCED-99-54, Washington DC: February 1999. While this report has been portrayed in the press as concluding that the IPP program is useless, in fact it concludes that "DOE's effort to supplement the salaries of former weapons scientists so that they do not sell their services to terrorists, criminal organizations, or countries of proliferation concern is laudable and, we believe, in our national security interests," and acknowledges that the program is successfully involving thousands of former Soviet weapons scientists in civilian projects. GAO expressed a number of valid concerns over "implementation and oversight," of the program, and made a range of recommendations, nearly all of which DOE has accepted. For a useful response to the GAO report and defense of IPP and the Nuclear Cities Initiative, see Biden, "Maintaining the Proliferation Fight in the Former Soviet Union," op. cit.

[37] Weiner, *Nuclear Cities News*, op. cit; see also the CRDF website, at www.crdf.org.

[38] For official discussions of the Nuclear Cities Initiative, see *Nuclear Cities Initiative: Program Strategy,* Washington, DC: U.S. Department of Energy, August 1999; *Nuclear Cities Initiative Program Plan*, Washington DC: U.S. Department of Energy, May 19, 1999; and the Nuclear Cities Initiative website, at http://nci.nn.doe.gov/ncihome.htm. For unofficial discussions, see Weiner, *Nuclear Cities News*, op. cit.; Bunn et. al., "Retooling Russia's Nuclear Cities," op. cit.; Kenneth N. Luongo, "The Nuclear Cities Initiative," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999; and *Nuclear Cities Initiative: Status and Issues*, op. cit..

[39] See *FY2001 DOE Budget Request to Congress*, op. cit.; and *Fact Sheet: Long-Term Nonproliferation Program for Russia,* op. cit.

foster sustainable employment for the roughly 50,000 people that MINATOM has indicated will need new jobs. The 50,000 figure is itself in all likelihood a substantial underestimate.[40] By agreement between the United States and Russia, the initial efforts focus on three priority cities—the two weapons laboratories (Sarov, formerly Arzamas-16, and Snezhinsk, formerly Chelyabinsk-70) and one of the plutonium production cities (Zheleznogorsk, formerly Krasnoyarsk-26). As Russia has recently announced that it plans to close two of its four nuclear weapons assembly/disassembly facilities (the Avangard plant located at Sarov, and the plant at Zarechniy, formerly Penza-19), DOE has proposed funding to help facilitate shut-down of these facilities and re-employment of their staff as well.

NCI has launched a number of commercialization and community-building programs in the nuclear cities. An Open Computing Center has been established in Sarov (with a similar center planned to open in 2000 in Snezhinsk), allowing computer experts from the weapons design laboratories to work on software development contracts for Western or Russian firms, at unclassified centers outside the nuclear weapons laboratories themselves. (As part of the agreements to establish these centers, U.S.-supplied high-speed computers that Russia had obtained without the proper export licenses are being moved from the weapons design labs to these open, unclassified centers, largely resolving any concerns that these computers might be used for weapons design.) An International Development Center has been established in Zheleznogorsk—with similar centers planned in Sarov and Snezhinsk—to foster development of private business in the town, by providing training and strategic planning services to businesses, helping the town government carry out economic development initiatives, and helping business make contact with potential sources of financing. NCI has also provided the initial funding necessary to allow businesses in the three initial priority cities to compete for the $300 million in small-business loans for Russia available from the European Bank for Reconstruction and Development (EBRD). A wide range of other specific projects are being explored or implemented—but the challenge is huge, the effort is only just beginning, and the resources provided to date are woefully inadequate to the task.

In short, as noted in Figure 1, if the problem is conceived of as providing short-term non-weapons opportunities that top weapons scientists can take if they so choose, a case can be made that programs currently under way are addressing a substantial fraction of the problem, perhaps 80 percent or more, at least in the nuclear area. But if the problem is conceived as achieving sustainable economics in a greatly downsized Russian nuclear complex that would pose less threat to the United States, the effort has barely begun—perhaps 10 percent of what would be needed to achieve that goal is now included in agreements and budget plans.

Monitoring Stockpiles and Reductions

Progress is even slimmer in bringing transparency to the management of nuclear weapons and nuclear materials, needed to lay the basis for effective long-term

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[40] *Report to the Congress on the Nuclear Cities Initiative*, reprinted in *Nuclear Cities Initiative: Status and Issues*, op. cit.

cooperation on security and accounting, and for deep reductions in nuclear warhead and material stockpiles.[41] A variety of informal approaches have made some headway: both sides (and particularly the United States) have unilaterally revealed substantial amounts of information about their nuclear stockpiles and complexes, and the level of U.S. and Russian access to the other side's nuclear facilities as part of the MPC&A program, lab-to-lab cooperation, and other programs that exists today would have been unthinkable as recently as early 1994. But formal transparency discussions between the two governments have produced virtually nothing but a trail of unfulfilled agreements (see "The Transparency That Never Happened," p. 47).

There have been three fundamental reasons for this lack of progress: (a) the legacy of 70 years of Communist secrecy (and a millenium of tzarist secrecy before that) has made Russia extraordinarily reluctant to open nuclear secrets; (b) many parts of the U.S. government have also been reluctant to open key U.S. facilities and operations to Russian examination (which has sometimes manifested itself in demands that Russia accept inspections in return for U.S. assistance, with no reciprocity on the U.S. side—a "pay-per-view" approach that has aggravated Russian suspicions of U.S. motives); and (c) the U.S. government's failure to offer any significant strategic or financial incentives that would make it in the interest of the relevant Russian officials to do the difficult and politically risky work of overcoming the many obstacles to moving forward with a broad nuclear transparency regime. In short, there is plenty of blame to go around on both sides—and these problems will inevitably be even more difficult to address with souring U.S.-Russian political relations, redoubled Russian reliance on nuclear weapons, and the intense U.S. focus on protecting nuclear secrets in the wake of the China spying scandals. But there remain opportunities, described below, for new transparency initiatives incorporating targeted incentives designed to ensure that initiatives genuinely serve the interests of both sides equally. A new Russian President in firm control of the government might be in a position to move in bold new directions, should he choose to do so.

Despite the lack of progress on the formal negotiating track, extraordinarily useful lab-to-lab cooperation is underway to analyze and develop technologies and procedures for confirming the dismantlement of warheads while protecting sensitive information. The goal of this effort is to have jointly developed approaches already available when

[41] For a useful current discussion of the status and prospects in this area, see Oleg Bukharin and Kenneth Luongo, *U.S.-Russian Warhead Dismantlement Transparency: The Status, Problems, and Proposals*, Princeton, NJ: Center for Energy and Environmental Studies, Princeton University, Report 314, April 1999. An overview of all the various U.S.-Russian programs in this area and how they fit together (or fail to) can be found in Bunn and Holdren, "Managing Military Uranium and Plutonium," op. cit. For an official description of the current priorities within DOE's program, see *Warhead and Fissile Material Transparency Program: Strategic Plan*, Washington DC: U.S. Department of Energy, May 1999. For discussions of what an overall transparency regime for warheads and fissile materials might look like, see National Academy of Sciences, Committee on International Security and Arms Control, *Management and Disposition of Excess Weapons Plutonium*, Washington DC: National Academy Press, 1994, Chapter 3; Steve Fetter, "A Comprehensive Transparency Regime for Warheads and Fissile Materials," *Arms Control Today*, January/February 1999 (available at http://www.armscontrol.org/ACT/janfeb99/sfjf99.htm); and Christopher Paine and Thomas Cochran, "Techniques and Procedures for Verifying Nuclear Weapons Elimination," in *Canberra Commission on the Elimination of Nuclear Weapons: Background Papers*, Canberra, Australia: Commission on the Elimination of Nuclear Weapons, 1996.

The Transparency That Never Happened

High level U.S.-Russian transparency commitments that have never been fulfilled, and initiatives that have never been implemented, include:

January 1994:	Presidents Clinton and Yeltsin agree on the objective of ensuring "transparency and irreversibility" of nuclear reductions and establish working group to work out specific measures. None of these measures have ever been implemented.
March 1994:	U.S. Secretary of Energy Hazel O'Leary and Russian Minister of Atomic Energy Mikhailov agree to mutual reciprocal inspection (MRI) of fissile materials from dismantled weapons beginning by the end of 1994. The inspections have never been implemented.
September 1994:	Presidents Clinton and Yeltsin agree to exchange data on warhead and fissile material stockpiles by the end of the year. The exchanges have never occurred.
May 1995:	Presidents Clinton and Yeltsin reaffirm their commitment to transparency and irreversibility, to mutual inspections of material from dismantled warheads, and to warhead and material data exchanges, and agree to have experts explore several other transparency possibilities. None of these measures have ever been implemented, and the Russian side cut off talks in late 1995, never to resume them during the remainder of Yeltsin's tenure in office.
September 1996:	Secretary O'Leary and Minister Mikhailov announce a "Trilateral Initiative" with the International Atomic Energy Agency (IAEA) to put excess fissile material under IAEA monitoring. (President Clinton had committed to place U.S. excess material under IAEA monitoring as early as 1993, and President Yeltsin had said in April, 1996 that he would place the Mayak storage facility being built for Russian excess nuclear material under IAEA monitoring.) While discussions continue, more than three years later no monitoring under the Trilateral Initiative has been implemented.
March 1997:	At their Helsinki summit, President Clinton and President Yeltsin agree that a START III agreement should include "measures relating to the transparency of strategic warhead inventories and the destruction of strategic nuclear warheads," and that transparency measures related to sea-launched cruise missiles, tactical nuclear weapons, and nuclear materials will also be explored. Three years later, as a result of the Russian Duma's failure to ratify START II and the U.S. refusal to begin START III negotiations until START II is ratified, no negotiations have begun, and it is expected that these issues will probably be dropped from START III in the interests of getting at least an initial framework agreement before President Clinton leaves office.

formal transparency negotiations begin.[42] DOE hopes to be able to establish new sites for demonstrating technologies and procedures for transparent warhead dismantlement at the two Russian nuclear weapons assembly and disassembly facilities now slated for closure, and at a comparable facility in the United States, such as the Device Assembly Facility (DAF) at the Nevada Test Site, and funding for this effort is included within the $10 million proposed for the two Russian nuclear weapons facilities in DOE's FY2001 budget request (see "DOE's Proposed Long-Term Nonproliferation Initiative for Russia," p. 70). This lab-to-lab effort, which also encompasses a number of other transparency issues, is perhaps the most promising U.S.-Russian transparency initiative now underway—but

[42]For a discussion, see *Warhead and Fissile Material Transparency Program: Strategic Plan*, op. cit.

here, too, souring political relations are contributing to difficulties relating to access to information and facilities.

Another informal initiative now in its early stages is the possibility of cooperation to put together data on Russia's current stockpile and historic production of weapons plutonium, comparable to the data the United States has already released.[43] Russian officials have indicated an interest in pulling together comparable data, and the United States sponsored a conference in Russia in which U.S. experts described for their Russian colleagues the work involved in preparing the U.S. plutonium inventory report, and the two sides discussed the work that would be involved in preparing a comparable Russian document. Open questions include whether Russia, if it did prepare such information, would be willing to make it available to the United States, and whether the United States would be willing to provide the financing needed to complete such a project.[44] Accomplishing a plutonium inventory data exchange through such an informal mechanism would provide a critically important precedent for additional transparency initiatives in the future, as well as laying a crucial foundation for cooperation on disposition of excess plutonium stockpiles.

Transparency arrangements for the Mayak storage facility—virtually the only formal U.S.-Russian transparency negotiation still underway as of late 1999—represent a classic example of the problems with the "pay-per-view" approach. The Russian side, while agreeing in principle from early on that in return for its assistance the United States could have access to this facility once it was built, delayed actually beginning negotiations for years on end, and has repeatedly raised the issue of the lack of reciprocity at similar U.S. facilities. This is a particular problem in this case, since under the earlier "mutual reciprocal inspections" (MRI) initiative, no longer being pursued, it was precisely this type of facility to which reciprocal access was to have been granted. Formal negotiations on Mayak transparency finally did get underway, and have largely reached agreement on the straightforward measures that would be implemented at the Mayak facility itself; but since Russia now plans to convert weapons components to metal slugs before the material is placed in this facility, the United States, to confirm that the material comes from weapons, is demanding transparency "upstream," at the facility where this conversion would be done. The United States has suggested a variety of measures to ensure that sensitive information about weapons component design would not be revealed, and has offered to demonstrate the techniques it proposes in a joint experiment on real U.S. weapons components, but has refused to offer reciprocal Russian monitoring for large-scale weapon component conversion in the United States. The Russian side is balking on accepting these unilateral upstream transparency measures.[45] Whether transparency measures will be developed and in place in time for the planned opening of the facility in 2002 remains to be seen.

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[43] For the U.S. release, see *Plutonium: The First 50 Years,* Washington DC: U.S. Department of Energy, 1996 (available at http://www.osti.gov/html/osti/opennet/document/pu50yrs/pu50y.html).

[44] Interviews with U.S. and Russian government and laboratory officials.

[45] For a discussion that is critical of the Mayak storage facility because of Russia's refusal to grant this upstream transparency, see General Accounting Office, *Weapons of Mass Destruction: Effort to Reduce Russian Arsenals May Cost More, Achieve Less Than Planned*, GAO/NSIAD-99-76, Washington DC: General Accounting Office, April 1999. For a general description of the types of measurements the United States is seeking, see *Warhead and Fissile Material Transparency Program Strategic Plan,* op. cit.

In parallel, the United States and Russia are also pursuing the concept of international, rather than merely bilateral, verification for excess material, under a "Trilateral Initiative" involving the United States, Russia, and the International Atomic Energy Agency (IAEA). Under the Trilateral Initiative, the three parties are working to develop a new verification regime that would allow the IAEA to confirm that fissile material had been irrevocably removed from nuclear weapons programs—including developing approaches to allow IAEA verification of material in classified forms, such as plutonium or HEU weapons components, without revealing classified information. The verification approach would be different from traditional IAEA safeguards, as the purpose would be focused on verifying reductions from stockpiles of thousands of nuclear weapons in nuclear-weapon states, rather than verifying that enough material for a single nuclear weapon has not been diverted in non-nuclear-weapon states.

The parties have carried out a number of technical demonstrations of relevant technologies (including a successful demonstration at Los Alamos in June 1999 of instrumentation with "information barriers," making it possible to confirm key attributes of fissile material in classified forms while blocking any classified information from being revealed to the inspector), and are working to draft a legal agreement outlining such a verification regime. Russia has indicated its intention to place the Mayak storage facility under this IAEA verification regime when the facility and the regime are both completed. At the June 1999 Board of Governors meeting, the IAEA secretariat outlined a number of options for funding such disarmament verification, including the creation of a special nuclear disarmament fund for this purpose.[46] Whether this initiative will come to fruition remains uncertain, however: many security concerns over having international inspectors monitoring such material have to be overcome, and funding remains a key issue that could block final agreement—not only funding for the IAEA's costs, but also funding for Russia's costs to host IAEA inspectors. In the meantime, as described below, the United States has been placing a modest portion of its fissile material under IAEA safeguards as part of its voluntary offer agreement with the IAEA.

Today, the only formal fissile material transparency measures actually being implemented on a substantial scale are, not surprisingly, the only ones where there was a large financial incentive to reach agreement—namely, the transparency measures for the $12 billion U.S.-Russian HEU Purchase agreement, designed to provide confidence to the United States that the LEU it is purchasing comes from HEU which in turn comes from weapons, and confidence to Russia that the LEU it is selling is used only for peaceful purposes.[47] Indeed, it is worth noting that Russian agreement to the more intrusive

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[46] For a discussion of progress on the trilateral initiative, see "IAEA Verification of Weapons-Origin Material in the Russian Federation and the United States," IAEA Press Release, General Conference PR 99/10, September 27, 1999 (available at http://www.iaea.org/GC/gc43/gc_pr/gcpr9910.html); see also Schiefer and Shea, "IAEA Perspectives," op. cit.

[47] The specific transparency measures being implemented include: occasional U.S. observation of measurements of containers said to hold HEU components of dismantled weapons, to confirm the presence of HEU with a U-235 content of at least 90%; occasional U.S. observation of the oxidation of metal shavings produced from these weapons components; checking of tags and seals of containers holding purified HEU after shipment to the blending facility; continuous monitoring of the flow of HEU, blendstock, and blended material at the blending facility, with permanent U.S. presence there; and copying and review of material accounting records provided by the Russian side. Russia is able to observe the

Transparency measures for the U.S.-Russian HEU Purchase Agreement include a permanent U.S. presence at the uranium enrichment plant at Novoural'sk (formerly Sverdlovsk-44), shown above. Transparency for the HEU deal—where there was a large financial incentive to reach agreement—is the only large-scale formal U.S.-Russian transparency initiative for warheads or fissile material that are being successfully implemented. Source: DOE

aspects of these transparency measures was gained by using the leverage provided by Russia's need for large cash pre-payments to provide the funding needed to carry out the operations to provide the LEU under the deal. For whatever reason, the United States government has never attempted to apply the basic lesson that transparency success requires there to be some incentive for the Russian side to reach agreement to its broader transparency objectives.

In short, if the objective is only to create one or two "transparency islands" relating to specific projects, such as the HEU Purchase Agreement and the Mayak Storage Facility, a large fraction of what is needed—perhaps 80 percent—is either already being implemented or at least under negotiation, as shown in Figure 1. But if the objective is to create a "sea of transparency" with only a few remaining "secrecy islands"—that is, to build the kind of comprehensive transparency regime that would be needed to help ensure security and provide a basis for deep reductions in nuclear warhead and material stockpiles—then the effort has barely begun: 5 percent or less of what would be needed can realistically be said to be underway.

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processing of the LEU delivered to the United States at USEC's enrichment plant, and fabrication of that LEU into reactor fuel at U.S. fabrication sites. As additional blending facilities have been added more rapidly than transparency measures for each facility could be negotiated and implemented, the most complete measures are so far only being implemented at the original blending facility, but are planned to be implemented at the others in the future. Because of this lack of complete implementation at the newer blending facilities, and because there is not a complete "chain of custody" with tags, seals, and monitoring ensuring continuity of knowledge throughout the entire process, there remain some skeptics who argue that there are possible ways to defeat the transparency regime and provide HEU that did not come immediately from weapons components, or even LEU that was not blended from HEU. Given the wide range of information available to the United States at different points in this chain, however, and given the minor to nonexistent incentives for Russia to provide material other than what has been agreed to, and the enormous financial risks to Russia of being caught violating the deal, there appears to be good reason for confidence that the LEU being purchased is in fact blended from HEU, most of which came from dismantled weapons. A brief discussion of these measures can be found in Janie Benton, et. al., "U.S. Transparency Monitoring Under the U.S./Russian Intergovernmental HEU-LEU Agreement," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999; see also *Nuclear Proliferation: Status of Transparency Measures for U.S. Purchase of Russian Highly Enriched Uranium*, GAO/RCED-99-194., Washington DC: General Accounting Office, September 1999. (Unfortunately, some of the more interesting transparency arrangements are the ones involving attempts to build confidence that the HEU came from weapons, which are not treated in the unclassified version of the GAO report.)

Ending Further Production

Ending the continued growth in the stockpiles of weapons-usable fissile material is another critical element of a comprehensive approach to managing these materials. The United States and Russia agreed in May 1995 that no fissile material produced in the future would be used in nuclear weapons. The United States has not produced HEU for weapons for decades (though HEU continued to be produced for submarine fuel until much more recently), stopped producing weapons plutonium in 1988, and does not produce either HEU or separated plutonium for civilian power or research purposes. Russia has indicated that it has not produced HEU for weapons for some time, but Russia still has three reactors producing weapons-grade plutonium—not because there is any need for that plutonium, but because those reactors provide essential heat and power for nearby communities. The 1.5 tonnes per year of plutonium that continues to be produced is stored in oxide form at the two reactor sites, Seversk (formerly Tomsk-7) and Zheleznogorsk (formerly Krasnoyarsk-26).

In 1994, the United States and Russia agreed to shut down these reactors by the year 2000, and to cooperate in providing alternative sources of heat and power to these communities. Initial studies of alternative energy sources, however—which did not fully explore all least-cost approaches, in part because of MINATOM's insistence on emphasizing nuclear replacement possibilities—suggested that the cost of replacement power sources would be high. In 1997 the two sides therefore agreed instead to convert the reactors to a different fuel cycle in which the reactors would produce very little plutonium, which would be of poor isotopic quality and embedded in spent fuel suitable for long-term storage without reprocessing. Appropriate monitoring would be put in place to ensure both that the reactors are in fact converted and that plutonium produced before then is not used in weapons.

Unfortunately, however, this effort has been bedeviled by bureaucratic, technical, safety, cost, and nonproliferation issues that have delayed progress and undermined political support. Early progress was delayed by bitter disputes between DOE and DOD over funding and tactics, which ultimately resulted in DOD providing funding for the project under the Cooperative Threat Reduction program and taking over its overall management, even while DOE laboratory experts continued to play the lead technical role.[48] Fuel development has taken longer than expected. Russia's nuclear regulatory agency has raised concerns that continuing to operate the production reactors at all poses serious risks of a Chernobyl-style accident, and has also raised specific concerns over the potential for the designs proposed for the converted reactor cores to contribute to the probability of such an accident; these concerns have yet to be fully addressed.[49] While

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[48] For a useful summary of the early days of the plutonium reactor conversion program, see Todd Perry, "Stemming Russia's Plutonium Tide: Cooperative Efforts to Convert Military Reactors," *Nonproliferation Review*, Vol. 4, No. 2 (Winter 1997). For an official description, see *Cooperation to Stop Weapons-Grade Plutonium Production in Russia: United States/Russian Federation Core Conversion Project*, Richland, WA: Pacific Northwest Laboratories, 1998 (available at http://insp.pnl.gov:2080/?coreconv/core_broch_p1).

[49] These reactors are the design on which the Chernobyl design was ultimately based. They have no containment vessels or emergency core cooling systems (though the one at Zheleznogorsk is deep

The top of the operating plutonium production reactor at Zheleznogorsk (formerly Krasnoyarsk-26), which produces half a tonne of weapons-grade plutonium each year. The United States and Russia are cooperating to convert this reactor and two more like it at Seversk (Tomsk-7) to a new fuel cycle that no longer produces weapons-grade plutonium, but the program is bedeviled by delays, cost-overruns, safety concerns, and nonproliferation issues related to the planned use of HEU fuel. Source: PNNL

the initial plan was for the United States and Russia each to pay half the cost of the conversion effort, with the U.S. share coming to approximately $80 million, the projected cost has since doubled, and in the wake of the August 1998 financial crisis, Russia indicated it would be unable to pay its share, bringing projected U.S. costs to over $300 million.

Moreover, in the spring of 1999, the U.S. government decided to fund development of both LEU and HEU fuels for this conversion program, and to accept at least initially the Russian preference to convert the cores to use the HEU fuel if, as expected, the HEU fuel becomes available first. The processing, fabrication, transport, and storage of hundreds of thousands of small, easily stealable HEU fuel elements each year could create serious proliferation risks if the most stringent practicable MPC&A measures are not applied throughout the process, and this reliance on HEU fuel, at least initially,

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underground, so that an accident would only contaminate the facility itself). The Russian nuclear regulators believe that continued operation of these reactors poses some of the most severe risks of a major nuclear accident in Russia, in part because decades of irradiation is causing the graphite blocks that make up the reactors' structure to swell and crack; under severe pressure from the Ministry of Atomic Energy, the regulatory agency granted the reactors a license to continue to operate for the time being in mid-1999, but only at a reduced power level. Although the conversion project includes a number of measures designed to significantly improve safety, including the addition of emergency core cooling systems, the Russian regulators question the adequacy of these measures, and argue that the proposed design could create new accident risks of its own. The specific design proposed for the converted cores involves alternating fuel elements and absorber elements in the vertical fuel channels in the reactors, creating an extraordinarily complex pattern of power and temperature highs and lows in each channel. The regulators argue that at the hottest points in this arrangement, the temperatures would come perilously close to those that could cause boiling of the coolant or melting of the coolant tubes, and that the computer models being used to analyze the safety of this design are not adequate to model such a complex arrangement and do not accurately replicate the current state of the reactors after decades of irradiation. These concerns are particularly credible as they are being raised by Alexander Dmitriev, deputy chairman of the Russian nuclear regulatory agency, who was the chief engineer for the two reactors at Seversk (Tomsk-7) for many years, oversaw their safety improvements after the Chernobyl disaster, and probably knows as much about their technical characteristics as anyone alive. Dmitriev again presented his concerns in written form to U.S. officials in September 1999, but many of these issues have not been resolved. The author is grateful to Frank von Hippel for discussions of these issues and access to a number of unpublished analyses on the plutonium reactor conversion program.

has seriously undermined whatever support this program had in the U.S. nonproliferation community.[50] Finally, although the original agreement called for all the reactors to be converted by the end of the year 2000, realistically it is now unlikely that any could be converted before 2003-2004—by which time they may only have a few years remaining during which the Russian regulators will continue to allow them to operate (after which replacement heat and power sources will be needed in any case).

Given the delays, skyrocketing costs, proliferation risks, and serious safety hazards involved in the conversion program, a strong case can be made that the United States and Russia should abandon the conversion effort and focus instead on least-cost approaches to providing alternative sources of heat and power, allowing these reactors to be shut down completely.[51] In early 2000, it was reported that Russia's Ministry of Atomic Energy had reached the same conclusion, and suggested to the United States that the funds slated for the conversion project should instead be spent to modify or complete several fossil-fired plants to provide the needed heat and power for the two cities, arguing that doing so would actually cost less—approximately $230 million—than current estimates for the conversion effort.[52] If, in fact, it can be confirmed that alternative energy sources can be provided for comparable cost in a comparable timeframe, this would be a dramatic breakthrough in this long saga, as this approach would address *both* the nonproliferation issues and the safety issues—without entangling the United States in supporting either the continued operation of fundamentally unsafe reactors, or the use of massive quantities of weapons-usable HEU fuel. At the same time, it would provide these towns with long-term energy supplies rather than converted reactors that would only last a few more years in any case. The critical next step is to perform a credible but quick-turnaround study of least-cost alternatives for providing the necessary heat and power for these two towns.

Meanwhile, as noted in Section II, Russia's civilian reprocessing at the RT-1 plant at Mayak also continues to separate plutonium—reactor-grade, but nonetheless weapons-usable—from spent nuclear fuel, adding nearly a tonne every year to the roughly 30 tonnes of this material already stored on site. In 1999, Minister of Atomic Energy Evgeniy Adamov publicly proposed a worldwide moratorium on plutonium reprocessing until new approaches that would not separate directly weapons-usable material are developed. At the same time, senior DOE officials were pursuing private discussions with Adamov of the possibility of a moratorium on reprocessing spent fuel from civilian power reactors. MINATOM's vision of its future is focused on playing a leading role in an ever-expanding global nuclear energy enterprise, which they believe will only be possible with reprocessing and recycling of plutonium, because of limitations on uranium resources. Moreover, hundreds of jobs, in a closed nuclear city with few other offerings, are dependent on the continuing reprocessing at Mayak—an issue that had stymied any

[50] See discussion in Frank von Hippel, presentation to the 6th International Policy Forum: Management and Disposition of Nuclear Weapons Materials, Exchange Monitor Publications, June 7-10, 1999.

[51] For a summary discussion of some of these issues, see Michael Knapik, "U.S. Urged to Look at Alternatives to Russian Reactor Core Conversion Project," *Nuclear Fuel*, December 27, 1999.

[52] See Michael Dobbs, "Russian Reactor Project Troubled: Moscow Asks to Halt Conversion to Civilian Use," *Washington Post*, February 13, 2000. The Russian cost estimate for alternative energy is far lower than the earlier estimates, in part because the Russians have greatly reduced their estimates of the amount of heat and power that must be provided.

Enormous Excess Stockpiles—And Still Larger Remaining Military Stocks

The United States and Russia have each declared enough fissile material for many thousands of nuclear weapons excess to their military needs. But the stockpiles of fissile material each country is holding in reserve for military uses are even larger than the amounts declared excess—easily enough to support stockpiles of well over 10,000 nuclear weapons.

As shown in Figure 2, the 174.3 tonnes of HEU the United States has declared excess represents only about a quarter of its estimated 645-tonne HEU stockpile.[1] All of the remainder is currently planned to remain in the military stockpile, for use in weapons or as naval fuel (enough, by one unclassified estimate of the average amount of HEU in modern thermonuclear warheads,[2] for more than 20,000 nuclear weapons). Indeed, with the exception of the first 10 tonnes of HEU declared excess, all of the HEU the United States has declared excess is HEU that did not meet the specifications for use as naval fuel; with that small exception, *all* of the material the Navy considered usable has been kept in military reserve. This remaining military stockpile is more than 40 percent larger than the 325 tonnes that would be needed to have both a stockpile of 10,000 weapons—as the United States reportedly plans to retain under START II—and a 100-tonne additional stockpile for naval fuel (enough for several decades' supply). Russia's excess declaration leaves it with an even larger remaining military stockpile of HEU, amounting to 550 tonnes or more.

Much the same situation pertains with respect to plutonium. While the United States has declared more than half of its plutonium stockpile excess, 18 tonnes of this excess material is either reactor-grade or fuel-grade, in spent fuel that was never separated, or in other forms so contaminated that they were never likely to be used in the U.S. weapons stockpile in any case. Of the 52.5 tonnes of excess plutonium, 34.5 tonnes is both weapon-grade and close enough to being pure to be judged to require substantial processing for disposition (and therefore to be included in the U.S.-Russian plutonium disposition agreement now being negotiated); of this, only 25 tonnes is actually pure weapon-grade metal—material directly suitable for use in nuclear weapons.[3] Somewhat more than 21 tonnes of this—less than half the material declared excess—actually came from recently dismantled nuclear weapons.[4] The United States is retaining roughly 47 tonnes of weapon-grade plutonium for weapons use (believed to be essentially all in clean metal form, representing nearly twice the amount of material in that form declared excess). By one unclassified estimate of the amount of material per weapon in modern thermonuclear weapons,[5] this represents enough for over 13,000 nuclear weapons.

In Russia, the situation is slightly more complex, as in different statements at different times, Russia has identified several categories of plutonium which it has pledged never to use in weapons. The 50 tonnes included in Russia's formal declaration of excess, unlike the U.S. excess material, is entirely weapon-grade metal coming from dismantled nuclear weapons. Because there is only 34 tonnes of roughly comparable material in the U.S. excess declaration, however, only 34 tonnes of the Russian excess will be covered in the U.S.-Russian disposition agreement now nearing completion, leaving 16 tonnes of the plutonium Russia has declared excess to be dealt with by some other means at a later time. In addition, Russia has pledged never to use its stockpile of civilian separated plutonium in weapons (30.3 tonnes as of the end of 1998,[6] growing by roughly a tonne per year as reprocessing continues), and it has also pledged that plutonium produced at its three remaining plutonium production reactors since October 1994 will never be used in weapons (amounting to roughly 7.5 tonnes by the end of 1999, growing at a rate of approximately 1.5 tonnes per year). Thus, the total quantity of Russian plutonium pledged to non-weapons use as of the end of 1999 stood at approximately 88 tonnes, out of a total estimated stockpile of over 160 tonnes of separated plutonium, both military and civilian. The 34 tonnes of plutonium to be covered in the U.S.-Russian agreement represents only about one-fifth of the total stockpile of Russian separated plutonium, and less than 40 percent even of the Russian plutonium already pledged to non-weapons use. If the 160-tonne total figure is roughly correct, it appears that Russia plans to retain over 70 tonnes of plutonium in its military stockpiles, enough for roughly 20,000 nuclear weapons.

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[1] The correct figure is actually less than one quarter, as the 645-tonne estimate is based on tonnes of equivalent 90% enriched HEU; since most of the 174.3 tonnes is at substantially lower enrichment levels, the equivalent number of tonnes of 90% enriched material would be much less than 174.3 tonnes.

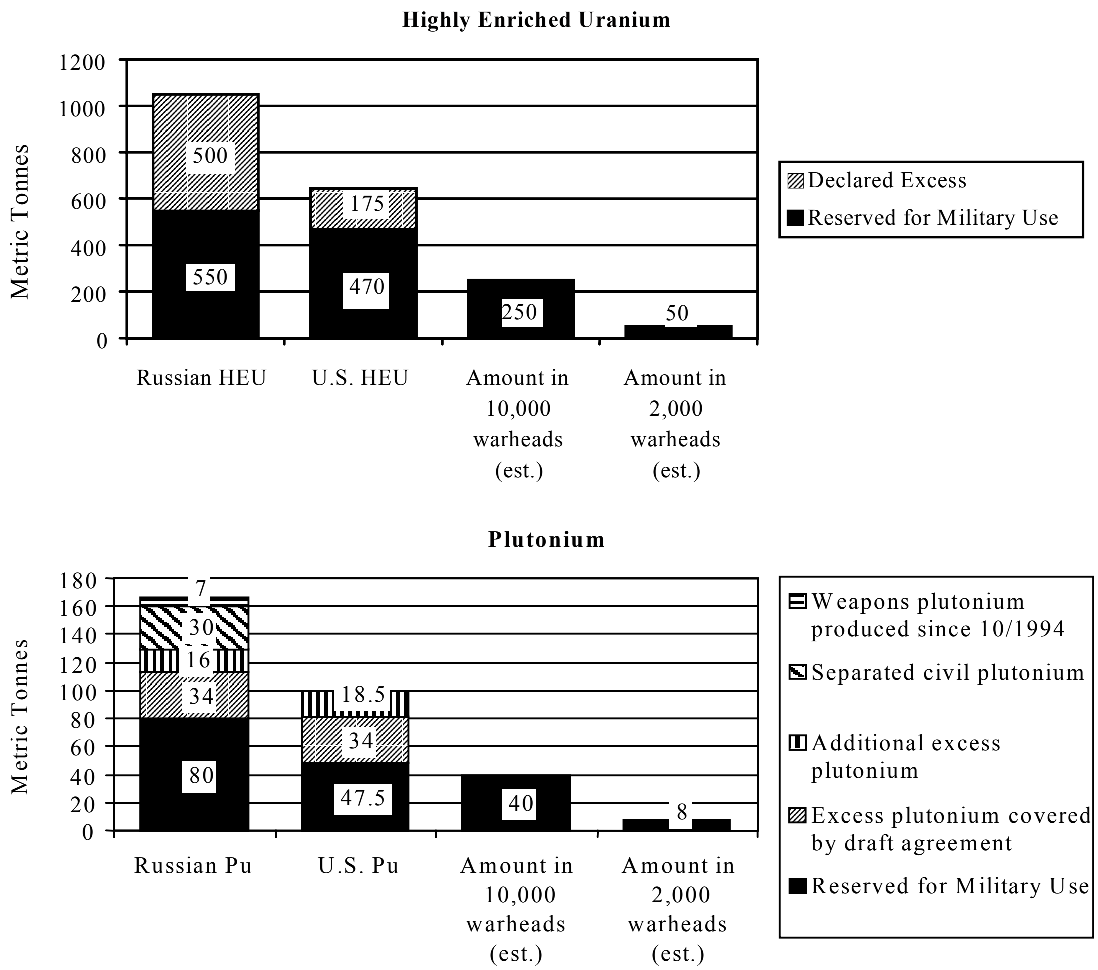

Figure Summary

Both the United States and Russia are retaining enough plutonium and HEU in military reserve to permit a rapid return to Cold War levels of nuclear armament. Substantial additional reductions in military plutonium and HEU stockpiles would be needed to bring them down to levels equivalent to 2,000 or even 10,000 nuclear warheads. Like the declared excess plutonium, civilian plutonium and plutonium produced since October, 1994 has been committed to non-weapons use. (This chart assumes 4 kilograms of plutonium per warhead and 25 kilograms of HEU, allowing a small allotment for material in the weapons maintenance pipeline compared to the 3.5 and 22.5 kilogram figures used in the text. Except for officially declared U.S. figures, all HEU figures are rounded to the nearest 10 tonnes, and all plutonium figures to the nearest tonne.)

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[2] Albright, Walker, and Berkhout, op. cit., provide an estimate of roughly 22.5 kilograms of HEU per weapon on average for the U.S. and Russian nuclear arsenals (p. 414).

[3] "U.S. Surplus Plutonium By Material Type and Disposition Pathway," Department of Energy, Office of Fissile Material Disposition, July 1999.

[4] The material in storage at Pantex and a small amount of the weapon-grade metal at other sites comes from recently dismantled nuclear weapons. For the amount of excess material at Pantex, see *Plutonium: The First 50 Years: United States Production, Acquisition, and Utilization from 1944 to 1994*, U.S. Department of Energy, 1996.

[5] Albright, Walker, and Berkhout, op. cit., estimate 3.5 kilograms of plutonium per weapon (p. 414).

[6] This is from the most recent official Russian declaration, which can be found in "Communication Received from Certain Member States Concerning Their Policies Regarding the Management of Plutonium," INFCIRC/549/Add.9/1, International Atomic Energy Agency, May 31, 1999 (available at http://www.iaea.org/worldatom/infcircs/99index.html).

discussion on the topic since it was last raised in 1994.[53] Hence, the idea of a moratorium on reprocessing was an extraordinarily sensitive one for DOE to venture into—yet in early 2000, senior DOE officials announced with their FY2001 budget that they believed they had reached an oral understanding with Adamov on a reprocessing moratorium. In return, DOE would provide funding for storage for the fuel that would not be reprocessed, and, if the U.S.-Russian disagreement over Russia's nuclear cooperation with Iran can be resolved, funding for joint research and development on advanced proliferation-resistant approaches to nuclear energy and its fuel cycle (see "DOE's Proposed Long-Term Nonproliferation Initiative for Russia," p. 70).

After the initial press reports of a deal, Adamov denied that there was any agreement, but acknowledged that there was "mutual understanding" on the subject of halting the accumulation of separated plutonium. There may still be difficult negotiations ahead, however, to translate the private discussions that have taken place into a formal agreement: Russian reprocessing advocates are already mobilizing, and are sure to raise the issues of funding for re-employing the workers at the reprocessing plant, compensation for termination of existing reprocessing contracts, and the like.[54] (Ironically, while the Department of Energy proposes to provide funding to stop reprocessing of civilian spent fuel at Mayak, the Department of Defense has entered into contracts to pay for reprocessing of naval fuel to continue at Mayak, at least for an interim period until adequate storage of fuel from decommissioned submarines can be provided.)

At the same time, for years MINATOM has in fact been seeking to raise the funds to finish construction of a huge new plutonium reprocessing plant known as RT-2. Located at Zheleznogorsk (formerly Krasnoyarsk-26) RT-2 was designed to separate tonnes of weapons-usable plutonium every year. In recent years, MINATOM has been seeking to modify Russian environmental laws so as to make it possible to accept foreign spent fuel for storage, and use the profits from that to build and operate RT-2. While at this writing it appears likely that the modification to the law will be approved in some form, it still appears highly unlikely that RT-2 will be built in the foreseeable future.[55] Indeed, some MINATOM statements have indicated that the plan for RT-2 is being abandoned, in favor of developing new reprocessing technologies that do not fully separate plutonium, and implementing these at other facilities decades in the future.[56]

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[53] In their January 1994 summit statement, Presidents Clinton and Yeltsin called for measures to halt the continued accumulation of fissile material. In the spring of 1994, when U.S. negotiators tried to turn this into a discussion of how to end the buildup of plutonium resulting from civilian reprocessing, they were told that the issue was not ripe for discussion, and privately Russian negotiators emphasized the critical importance of the jobs issue.

[54] For Adamov's public suggestion of such a moratorium, see, for example, Adamov's prepared statement for the "International Conference on Geologic Repositories," U.S. Department of Energy, Denver, CO, November 1-2, 1999; for a report that agreement had already been reached (premature, as it turned out), see Judith Miller, "Moscow Takes Step to Ease U.S. Fears on Plutonium Use," *New York Times*, February 7, 2000; for Adamov's denial of either an agreement or negotiations on one, see *Nuclear News*, February 10, 1999.

[55] For a critical summary, see Igor Kudrik, "MINATOM Lobby for Spent Fuel Intensifies," *Bellona*, April 23, 1999.

[56] See Mark Hibbs and Ann MacLachlan, "MINATOM Ends Plans to Reprocess at Krasnoyarsk, Will Upgrade Mayak," *Nuclear Fuel*, November 2, 1998, reporting statements by First Deputy Minister of Atomic Energy Valentin Ivanov. Other statements suggest the plant is still planned.

This latter approach would be consistent with the proposed reprocessing moratorium, while the original RT-2 plan clearly would not. A number of analysts—including the author—have proposed a different approach in which Russia would accept foreign spent fuel for storage, but would use the revenue for nonproliferation and cleanup activities (see “Generating New Revenue for Nuclear Security,” p.86).

At the same time, there are no transparency or verification measures in place at U.S. and Russian enrichment plants to confirm that no HEU is being produced—or, for that matter, at U.S. and Russian reprocessing plants, to confirm that none of the plutonium or HEU being separated is being used for nuclear weapons. While a global fissile cutoff agreement that would impose such verification—at least in the U.S. conception—is being discussed at the Conference on Disarmament in Geneva, little progress has been made, and the Russian position on this treaty would exempt most relevant Russian facilities from verification.[57]

In short, as suggested in Figure 1, if the goal is only to see the Russian plutonium production reactors converted or shut down, planned budgets and agreements are in place to carry out the large majority of the required work—though even there, much remains to be resolved before success can be claimed. There are also new proposals from DOE to address the continued separation of civilian plutonium in Russia. Between them these efforts represent a substantial fraction, perhaps half, of the work required to verifiably put a stop to the continued growth of the vast stockpiles of weapons-usable plutonium and HEU in Russia and the United States. To complete the job will require putting in place verification at all the reprocessing and enrichment facilities capable of producing such materials in the two countries, a task that has not yet begun.

Reducing Fissile Material Stockpiles

With the end of the Cold War and the consequent dismantlement of thousands of nuclear weapons, both the United States and Russia have enormous stockpiles of plutonium and HEU they no longer need. These huge stockpiles will pose serious proliferation and arms-reduction-reversal risks as long as they remain in readily weapons-usable form. As former Russian Minister of Atomic Energy Victor Mikhailov once said, “Real disarmament is possible only if the accumulated huge stocks of weapons-grade uranium and plutonium are destroyed.”[58]

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[57] For a brief discussion of the status of the fissile cutoff talks, and information on the Russian position and its implications, see George Bunn, “Fissile Material Cutoff Treaty: What Added Inspections Would it Require of Civilian Nuclear Power Facilities?” in *Proceedings of Global '99: Nuclear Technology-Bridging the Millenia*, Jackson Hole, Wyoming, 30 August-2 September 1999, La Grange Park, IL: American Nuclear Society, 1999. See also, for example, William Walker, “Policies on Fissile Materials: The Cutoff Treaty and Existing Stocks,” in David Albright and Kevin O'Neill, eds.: *The Challenges of Fissile Material Control,* Washington DC: Institute for Science and International Security, March 1999, pp. 29–40, and the papers prepared for the “Fissile Material Information Workshop,” co-sponsored by the Institute for Science and International Security (ISIS) and the Permanent Mission of Canada to the United Nations, Geneva, January 25-26 1999, Geneva, Switzerland (available at http://www.isis-online.org).
[58] Address to the International Atomic Energy Agency, quoted by TASS, September 22, 1992.

Russian Perspectives on Disposition of Excess Weapons Plutonium

The dominant perspectives on disposition of excess weapons plutonium among Russian policymakers are strikingly different from those of U.S. policymakers—a fact that continues to require delicate negotiation to build agreements that both sides see as serving their interests.

The U.S. approach to disposition of excess weapons plutonium can be summed up in five basic principles:

- Excess weapons plutonium is primarily a security issue; because of the urgency of the security threats it poses, this material should be transformed into forms that are no more attractive for recovery and use in weapons than plutonium in spent fuel as rapidly as this can be safely and securely accomplished.
- Disposition of Russian and U.S. excess weapons plutonium should proceed in a balanced way, ending ultimately with roughly equal levels of material remaining in military stockpiles—meaning that at some point Russia, which begins with a larger military stockpile of plutonium, will have to carry out greater reductions in that stockpile.
- Excess weapons plutonium has no economic value, since the cost of using it to produce nuclear energy is more than the energy is worth. Indeed, it is a substantial economic liability, since all options for its disposition will cost billions of dollars—but it is worth paying those costs for the resulting decrease in security threats.
- Because of the security dangers posed by separated plutonium, and the high costs of separating and managing it, civilian plutonium should not be reprocessed and recycled, even if some portion of excess weapons plutonium is used as reactor fuel as the most effective way to meet the security objectives of disposition. The United States should not provide material support to recycling of civilian plutonium, in Russia or elsewhere.
- Decisions on disposition of excess weapons plutonium and on the future of nuclear energy should be made separately, since the stockpiles of excess weapons plutonium are tiny in the overall global energy resources picture, and decisions on nuclear energy can be made over a period of decades, while disposition of excess weapons plutonium is comparatively urgent.

The U.S. decision to undertake a multi-billion-dollar program in which some of its excess weapons plutonium would be used as reactor fuel (once-through, with no reprocessing, and with the plutonium fuel facilities to be shut and torn down after the excess weapons plutonium mission is accomplished), and some would be immobilized with high-level wastes, was based on these basic principles.

While the U.S.-Russian Independent Scientific Commission on Disposition of Excess Weapons Plutonium, which included experts from both Russia and the United States, reached a consensus on similar principles,[1] the majority opinion among Russian policymakers, particularly within the Ministry of Atomic Energy, is strikingly different. This dominant Russian view is aptly summed up in an interagency "concept" for disposition of excess weapons plutonium drawn up under MINATOM's chairmanship in 1998.[2] The view expressed in this official concept can be summed up in the following five principles:

- Excess weapons plutonium is primarily an energy issue: this plutonium has "significant energy potential" and its production "required great investments in material, labor, and financial resources." It should be seen as an energy resource, along with civilian plutonium, and it is therefore acceptable to keep storing the material for now, with disposition taking place over "several decades," a timescale "comparable with the timetables for the development and assimilation of new technologies in nuclear energy."

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[1] *Final Report of the U.S.-Russian Independent Scientific Commission on Disposition of Excess Weapons Plutonium,* op. cit.

[2] *Concept of the Russian Federation: Disposition of Plutonium Withdrawn During the Course of Nuclear Disarmament*, 1998. The working group that prepared the document was chaired by First Deputy Minister of Atomic Energy Lev Ryabev, and included representatives from most of the main departments of MINATOM and a variety of MINATOM enterprises, as well as the Ministry of Defense and the Kurchatov Institute.

- Excess weapons plutonium does also have a "political aspect" relating to the irreversibility of nuclear arms reductions (the issue of the risk of theft of such material is not mentioned as a reason to pursue disposition, except in statements that it must be adequately protected from theft). In accordance with this irreversibility objective, a "basic condition" is that "disposition of withdrawn weapons plutonium in Russia and in the USA must proceed in parallel"—and there should be equal reductions in U.S. and Russian plutonium stockpiles, not reductions to equal levels. "The quantities of plutonium that will remain necessary for purposes of national security in Russia and in the USA may not coincide."
- Excess weapons plutonium has enormous energy value, but at present its use as fuel would involve substantial additional costs (estimated in the paper to be roughly $1.5 billion, although different reactor options are presented that would have somewhat different costs). Therefore, if for political reasons other countries want Russia to carry out disposition sooner than it would make economic sense to do so, they should pay the cost: "*a condition for the implementation of the comprehensive use of withdrawn weapons plutonium in the Russian nuclear power industry is that Russia's added expenditures be covered by the United States and other countries interested in the fastest and guaranteed conversion of Russian weapons plutonium into forms unsuitable for use in nuclear weapons."* (emphasis in original)
- Plutonium recycling, ultimately in fast-neutron breeder reactors, is a desirable and essential part of the future of nuclear energy.
- Given the substantial energy content of the plutonium, decisions on disposition of excess weapons plutonium must be an integral part of decisions about the future of nuclear energy. "[T]he problem of disposition of these fissile materials must be resolved within the framework of a national strategy for the development of nuclear energy. This strategy is aimed at the gradual transition to a closed fuel cycle with the use of fast neutron reactors powered by plutonium."

Given these principles, the concept concludes that "the aim of disposition of withdrawn weapons plutonium is its use in the nuclear power industry," and approaches such as immobilization that do *not* make use of the energy value of the plutonium "will not be implemented." Disposition should include "the development of production processes and technologies of a closed fuel cycle with fast reactors, all the while observing international standards of safety and nonproliferation."

The draft agreement now nearing completion is designed to accommodate most of both sides' basic principles. It commits Russia to move quickly on plutonium disposition, as the United States would prefer—but only if funds to cover the extra costs become available from the United States and other parties. A MOX plant built with international assistance in Russia is to be used only for disposition of excess weapons plutonium as long as that mission lasts—postponing the argument about what happens then for decades into the future. The United States will not help Russia finance and build new fast-neutron reactors, but there is no prohibition on Russia doing so, if it can find the money somewhere. For this first step, there will be equal reductions in plutonium stockpiles, but that does not resolve whether ultimately there should be reductions to equal levels. Russia will use all of its plutonium covered by the agreement, but the United States will use some as fuel and immobilize the rest (though Russian opposition to immobilization extended to seeking limits on the amount of U.S. plutonium that would be immobilized, on the argument that immobilized material could more readily be recovered for use in weapons than material that had been used as MOX[3]). With flexibility, persistence, and a bit of luck, it may be possible to continue to bridge these basic disagreements for the decades that will be required to complete disposition of the U.S. and Russian excess weapons plutonium.

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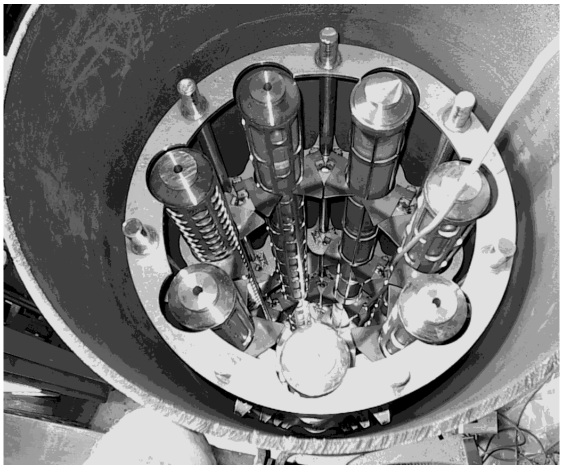
[3] This is more a talking point than a serious strategic concern, since the United States is holding far larger quantities of material in reserve in the form of assembled warheads and plutonium pits ready to be assembled into such warheads. Moreover, as a variety of studies have concluded, it will cost more than a billion dollars for the United States to immobilize its plutonium, and would probably cost nearly as much to get it back out, should a decision be taken to do so, offering a substantial degree of "irreversibility" for the process. Indeed, plutonium that had been irradiated as MOX could also be recovered in similar fashion; while its isotopics would have been degraded by reactor irradiation, nuclear weapons can be made from such reactor-grade plutonium with yield, weight, and reliability comparable to weapons made from weapon-grade plutonium.



A portion of the U.S. excess weapons plutonium is to be immobilized with high-level radioactive wastes in the so-called "can-in-canister" immobilization form, shown here. Cans of weapons plutonium immobilized in ceramic are arrayed within a large canister, into which molten glass mixed with high-level waste is poured, making a massive, highly radioactive glass "log," protecting the plutonium from theft or recovery for use in weapons. Source: DOE

Yet progress in accomplishing that objective has been modest, to date.

Recognizing the reality that their fissile material stockpiles vastly exceed their current military requirements, both the United States and Russia have designated hundreds of tonnes of their fissile material stockpiles as being "excess" to their military needs, and pledged that this material will never again be used in nuclear weapons. The United States has designated 52.5 tonnes of plutonium as excess, along with 174.3 tonnes of HEU, for a total of just over 225 tonnes of excess fissile material.[59] Russia has designated "up to" 50 tonnes of plutonium and 500 tonnes of HEU as excess.[60] The United Kingdom has also declared more than 4 tonnes of plutonium excess.[61] Unfortunately, both the United States and Russia are still retaining even larger amounts of material in stockpiles reserved for military use—easily enough to support a rapid return to Cold War levels of armament, and to pose enormous risks of theft. (See "Enormous Excess Stockpiles—And Still Larger Remaining Military Stocks," p. 54.) Current programs designed to ensure that excess material is never again used in weapons can make a major contribution to both countries' stated goals of ensuring the irreversibility of nuclear disarmament and preventing nuclear proliferation—but only if

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[59] *Feed Materials Planning Basis for Surplus Weapons-Usable Plutonium Disposition,* Washington DC: Department of Energy, Office of Fissile Material Disposition, April 1997.

[60] Boris Yeltsin, *Message from the President of the Russian Federation to the Forty-First Session of the General Conference of the International Atomic Energy Agency,* September 26, 1997. The actual Russian language was that "up to" these figures had "become available through the nuclear disarmament process" and would be "remove[d] gradually from military nuclear programs," with the pace of this "dependent both on progress with the dismantling of nuclear weapons pursuant to existing agreements on nuclear disarmament, and on the creation of the necessary storage facilities for the material released from military use."

[61] The United Kingdom has declared 0.3 tonnes of weapons-grade plutonium, and 4.1 tonnes of non-weapons-grade plutonium excess to its military needs, along with 9,000 tonnes of natural or low-enriched uranium that had been held in military stocks for fueling military production reactors, and is placing these materials under EURATOM safeguards; they are is available for IAEA safeguarding, but the IAEA has not chosen to safeguard it because no funding is available to do so. These are from declared total stockpiles outside of safeguards of 7.6 tonnes of plutonium, 21.9 tonnes of HEU, and 15,000 tonnes of natural and low-enriched uranium. All of the HEU is to be held in military stockpiles for use either as weapons or as naval fuel. See "Communication Received from the United Kingdom of Great Britain and Northern Ireland: United Kingdom Fissile Material Transparency, Safeguards, and Irreversibility Initiatives," INFCIRC/570, Vienna, Austria: IAEA, September 21, 1998 (available at http://www.iaea.org/worldatom /infcircs/infcirc570.html), and discussion in Schriefer and Shea, "IAEA Perspectives on Excess Materials," op. cit.

they represent a first step toward dealing with much larger portions of the U.S. and Russian fissile material stockpiles in the future. As arms reductions proceed, these stockpiles should be reduced in parallel to roughly equivalent levels in the United States and Russia, suitable to support whatever agreed warhead levels remain, but not large enough to permit a rapid return to Cold War levels of armament.

Disposition of U.S. Fissile Material

The United States has publicly committed to place its excess material under IAEA verification, to confirm that it will never be returned to weapons. But as of the end of 1999, only a very small fraction of the material had actually been made available for verification.[62]

The excess HEU is being blended to LEU at U.S. facilities, for sale on the commercial reactor fuel market (or disposal, in the case of material that is too contaminated to have commercial value). Blending of the first 14.3 tonnes of this material (enriched to 75% U-235) was completed at USEC's Portsmouth enrichment plant in July 1998. An additional 50 tonnes (enriched to 40 percent U-235) has been transferred from DOE to USEC and is now being blended, with that process expected to be completed in 2005. Finally, DOE and the Tennessee Valley Authority (TVA) have agreed that 38 tonnes of off-specification material (enriched to 65% U-235) will be blended and burned in TVA plants over several years, with full-scale loading of the blended material now expected to begin in 2003-2004.[63] DOE is still making plans for disposition of the remaining excess HEU.

For the excess U.S. plutonium, a substantial program is in place to demonstrate and implement two complementary disposition paths: a portion of it is to be burned as

[62] The United States had officially stated that 38 tonnes of material would be made available for IAEA safeguards by the end of 1999 (see *Fact Sheet: U.S. Commitment to the Treaty on the Non-Proliferation of Nuclear Weapons*, op. cit.), but it appears that the actual amount made available by that time was roughly half that figure. The 38 tonne figure included 12 tonnes already under IAEA safeguards (2 tonnes of plutonium at Hanford and Rocky Flats, and 10 tonnes of HEU at Oak Ridge), 13 tonnes blended at the Portsmouth enrichment plant by 1998, and 13 additional tonnes of the 50 tonnes transferred to USEC from DOE when USEC was privatized in 1998. But of the 13 tonnes downblended at Portsmouth (ultimately 14.3 tonnes rather than the originally planned 13), the amount downblended during the verification "experiment" the IAEA was permitted to perform (for technical reasons, the United States and the IAEA determined that no genuine "safeguards" approach was feasible for that process at that facility) was only 3.7 tonnes, bringing the total verified by the IAEA to 15.7 tonnes as of the end of 1998. While it is planned to make the 50 tonnes transferred to USEC available for IAEA verification as it is downblended, under current plans it would not be made available for verification while in storage awaiting downblending, and only a small (undisclosed) amount had been downblended as of the end of 1999. For discussions of these amounts, see Schriefer and Shea, "IAEA Perspectives on Excess Materials," op. cit.; Amy B. Whitworth, "Implementation of International Inspections in the United States," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999, and Nevile E. Whiting and Will Theis, "Portsmouth: The Conclusion," in the same volume.

[63] See John Longenecker and Ron Witzel, "Enrichment in a World of Privatization," *Nuclear Engineering International*, September 1999; "Megatons to Megawatts Program Status as of August 1998," press release, U.S. Enrichment Corporation (http://www.usec.com/Structure/Navigation/ThirdTier/newsreleases/09-22-98.htm); and Wayne Barber, "Plans for HEU Reloads Moving Slowly Through DOE, TVA," *Nuclear Fuel*, December 27, 1999.

The Expanded Threat Reduction Initiative

In his January 19, 1999 State of the Union address, President Clinton announced an Expanded Threat Reduction Initiative (ETRI), saying "we must expand our work with Russia, Ukraine, and the other former Soviet nations to safeguard nuclear materials and technology so they never fall into the wrong hands. Our balanced budget will increase funding for these critical efforts by almost two-thirds over the next five years."

Unfortunately, it soon became clear that the claimed two-thirds increase in spending for these programs to "safeguard nuclear materials and technology" was illusory. This was a peculiarly Washington kind of "increase"—judged not by comparing proposed spending to current spending, but by comparing proposed spending to previously planned deep cuts in spending. In reality, under the proposal, funding for most programs related to safeguarding nuclear materials and technology was to remain roughly flat, not increase. Much of what "increase" there was went to worthy efforts unrelated to safeguarding nuclear material, from providing civilian jobs for biological weapons experts to dealing with left over conventional ammunition in the Trans-Dniestr area of Moldova.[1]

The budget for the MPC&A program—the main program most directly dealing with safeguarding nuclear materials—tells the story. In FY1999, when the scope of the nuclear material emergency following the August 1998 financial meltdown became clear, rather than reprogramming additional funds for nuclear material security, DOE took funds away, redirecting $12 million of the $152 million Congress had appropriated for work on other projects. The much-vaunted "increase" for MPC&A in the Expanded Threat Reduction Initiative was a request for FY2000 of $145 million—$7 million *less* than Congress had appropriated the year before (though more, to be sure, than DOE had once planned to request, when the program had been slated to decline rapidly toward zero). A substantial amount of bureaucratic infighting was required even to bring the budget to that "not quite flat" level. The gap between the Administration's rhetoric and its budgeting could hardly be more stark.

Overall, the Expanded Threat Reduction Initiative package called for $4.2 billion dollars in spending on a wide range of programs over 5 years, compared to $2.5 billion that had been previously planned for that period, or somewhat over the $3 billion that would have been spent had FY1999 expenditures (except for one-time initiatives such as the Domenici HEU and plutonium funding) been kept constant for five years.[2] Roughly two-thirds of the planned spending is for programs related, in one way or another, to warhead and fissile material control—but few of these are substantially increased compared to the FY1999 funding that existed before the initiative was launched. The table below compares: (a) appropriated funding for these programs for FY1999, before the initiative, (b) the Administration's request for FY2000, the first and largest year of the new initiative;

[1] See *Expanded Threat Reduction Initiative*, op. cit.
[2] Alternatively, the $4.2 billion can be compared to over $3 billion, which would have been the result of keeping previous spending levels constant for the five-year period, making the result closer to a one-third increase than a two-thirds increase.

uranium-plutonium mixed oxide (MOX) fuel in existing U.S. reactors, and the remainder is to be immobilized with high-level wastes.[64] Recovering plutonium for use in weapons

[64] For a detailed discussion of the options for plutonium disposition and the status as of 1997, see Bunn and Holdren, "Managing Military Uranium and Plutonium," op. cit., and sources cited therein; see also *Final Report of the U.S.-Russian Independent Scientific Commission on Disposition of Excess Weapons Plutonium*, Washington DC: Office of Science and Technology Policy, June 1997 (available at http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/atom). A variety of current official program documents and briefings are available at the program website, at http://twilight.saic.com/md/; a particularly useful short official overview can be found in Laura S.H. Holgate, "Plutonium Disposition: A Case Study of Nuclear Materials Management," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999.

(c) Congressional appropriations for that year; and (d) the Administration's request for FY2001, when it proposed some new efforts focused on security and monitoring of nuclear materials (see "DOE's Proposed Long-Term Nonproliferation Initiative for Russia," p. 70). As can be seen, the ETRI request held most of the programs roughly constant; the most substantial increases were for science cooperation programs that provide grants to former weapons scientists (including the International Science and Technology Centers, the Initiatives for Proliferation Prevention, and the Civilian Research and Development Foundation), many of which go to biological, chemical, or aerospace experts rather than nuclear experts. When these efforts are excluded, the Administration's request for programs related to safeguarding warheads and fissile materials for FY2000 was only 5 percent more than Congress appropriated in FY1999.

After fights over a variety of specific issues, Congress in the end approved a large fraction of the first year's funding for ETRI.[3] For programs related specifically to warhead and fissile material security, Congressional action increased funding.

As the following year's budgets were being prepared, with a presidential election underway, senior White House officials paid only modest attention to any organized attempt to set nuclear security priorities. In January, 2000, ETRI went unmentioned in President Clinton's longest State of the Union speech yet, and safeguarding nuclear material rated only a few-word phrase—though the actual budget, released two weeks later, included a $100 million new initiative devoted to that objective (see "DOE's Proposed Long-Term Nonproliferation Initiative for Russia," p. 70). At the same time, however, the Administration requested less than it had projected the year before for various other parts of ETRI, so the overall size of the ETRI effort did not increase significantly with this new proposal.[4]

In short, the Expanded Threat Reduction Initiative provided a modest amount of additional funding for warhead and fissile material control efforts, as well as for other worthy endeavors, and it deserves continuing support. But it fell far short of what is needed to address the urgent proliferation threats posed by nuclear materials in the former Soviet Union, and far short of what the President announced to the nation. Even the new initiative unveiled in February, 2000, while a useful step in the right direction, is only a fraction of what needs to be done to address the urgent security risks the United States now faces.

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[3] For a detailed accounting of Congressional authorization and appropriation actions in FY2000 for programs in the Expanded Threat Reduction Initiative, see *Russian Nuclear Security and the Expanded Threat Reduction Initiative: A Summary of Congressional Reaction*, Washington DC: Russian-American Nuclear Security Advisory Council, forthcoming (2000).

[4] For a description of the latest initiative, see "Fact Sheet: Long-Term Nonproliferation Program for Russia," U.S. Department of Energy, February 7, 2000. Reductions in other areas include, for example, a budget for DOD's Cooperative Threat Reduction Program roughly $50 million less than had been projected in the 1999 Expanded Threat Reduction Initiative proposal, a Nuclear Cities Initiative budget that is more than $12 million less than projected, an Initiatives for Proliferation Prevention budget that is over $7 million less than projected, and so on (FY2001 budget documents).

from the massive, highly radioactive waste forms from either of these processes would be roughly as difficult and unattractive as recovering it from the vastly larger quantities of ordinary commercial spent nuclear fuel that already exist—the so-called "spent fuel standard." A final record of decision outlining DOE's plans to implement both of these approaches was issued in January, 2000.[65] For either of these approaches, plutonium will have to be converted from weapons components or other forms to oxide; a prototype

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[65] See *Record of Decision for the Surplus Plutonium Disposition Final Environmental Impact Statement*, Washington DC: U.S. Department of Energy, January 4, 2000; and *Surplus Plutonium Disposition Final Environmental Impact Statement* (3 vols. and summary), DOE/EIS-0283, Washington DC: U.S. Department of Energy, Office of Fissile Materials Disposition, November 1999.

facility for that purpose was dedicated at the Los Alamos National Laboratory in September, 1998, and a full-scale facility at Savannah River is expected to begin operations in fiscal 2006. A commercial contract for the initial design stages of the MOX portion of the program—with options for later stages—was signed in March 1999, with a full-scale MOX fuel fabrication facility at Savannah River also expected to begin operations in 2006 (after initial MOX test assemblies are fabricated at Los Alamos). Full-scale "hot" (radioactive) tests of the immobilization approach are expected in a few years, with operation of a full-scale plant to follow in 2008. While the disposition of the HEU will return funds to the U.S. Treasury from the material's commercial value, plutonium has no value in the current market, as noted above, and hence the U.S. plutonium disposition program is expected to cost in the range of $4 billion (roughly twice earlier estimates).[66]

The immobilization track has faced technical difficulties that have delayed its progress and increased its cost, including the failure of the previously planned process for vitrifying high-level waste at the Savannah River Site. (The vitrified high-level waste is to provide the radiation barrier to deter theft in the planned "can-in-canister" disposition concept, in which the plutonium would be immobilized in ceramic, and small cans of this ceramic would be arrayed in the large canisters into which intensely radioactive high-level waste glass is poured.[67]) The MOX track, meanwhile, has been criticized by a broad range of non-governmental organizations on grounds of undermining the U.S. opposition to civilian plutonium recycling. Defenders have countered that what the U.S. has long opposed is making *more* separated, weapons-usable plutonium, and that using all the available means to *reduce* stockpiles of separated plutonium is completely consistent with this policy.[68] The politics of the use of plutonium in U.S. reactors remains deeply problematic, however, and it remains to be seen whether DOE will succeed in carrying out this part of the program. It was precisely because of the likelihood of technical

[66] These planned dates and cost estimates are from *Plutonium Disposition Life Cycle Costs and Cost-Related Comment Resolution Document*, DOE/MD-0013 Rev. 0, Washington DC: U.S. Department of Energy, Office of Fissile Materials Disposition, November 1999. The $4 billion figure is an undiscounted total life cycle cost in 2000 dollars. For earlier official estimates, see *Cost Analysis in Support of Site Selection for Surplus Weapons-Usable Plutonium Disposition*, Rev. 0, Washington DC: Department of Energy, Office of Fissile Materials Disposition, July 22, 1998; and *Technical Summary Report for Surplus Weapons-Usable Plutonium Disposition*, Rev. 1., Washington DC: U.S. Department of Energy, Office of Fissile Materials Disposition, November 1996 (which provided an estimate of roughly $2 billion for a similar hybrid option). All of these reports are available at the Office of Fissile Materials Disposition web page, at http://twilight.saic.com/md/.

[67] For discussions of the can-in-canister concept and how difficult it would be retrieve plutonium immobilized in this way, see *Nonproliferation and Arms Control Assessment*, op. cit.; and John P. Holdren (chair) et. al., *Interim Report,* Panel to Review the Spent-Fuel Standard for Disposition of Excess Weapons Plutonium, Committee on International Security and Arms Control, National Academy of Sciences July 1999.

[68] For a summary of the critics' view, see Edwin S. Lyman and Paul Leventhal, "Bury the Stuff," *Bulletin of the Atomic Scientists*, March-April 1997; for a summary of the supporters' view, see John P. Holdren, John F. Ahearne, Richard L. Garwin, Wolfgang K.H. Panofsky, and Matthew Bunn, "Excess Weapons Plutonium: How to Reduce a Clear and Present Danger," *Arms Control Today*, November-December, 1996. For a direct response to the main criticisms, see Matthew Bunn, "The Case for a Dual-Track Approach—And How to Move Forward From Here," *Nuclear Materials Monitor*, Vol. 1, No. 5, July 14 1997 (available at http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/atom).

obstacles for the immobilization track and political obstacles for the MOX track that a panel of the National Academy of Sciences originally recommended pursuing both in parallel, so that each could serve as a backup to the other.[69]

Disposition of Russia's Excess HEU: The HEU Purchase Agreement

Disposition of Russia's 500 tonnes of excess HEU from dismantled weapons is covered by the U.S.-Russian HEU Purchase Agreement, under which this material is being blended to LEU and sold to the United States for re-sale on the commercial reactor fuel market. This is perhaps the most important and creative single U.S.-Russian fissile material control program. At one stroke, the HEU purchase provides financial incentives to dismantle thousands of warheads, destroys hundreds of tonnes weapons-usable material that could otherwise pose risks of proliferation or arms-reduction reversal, provides employment to thousands of Russian nuclear workers, and provides hundreds of millions of dollars a year to the desperate Russian nuclear complex—all (until recently) at virtually no net cost to the U.S. taxpayer. By the end of 1999, almost 75 tonnes of HEU—enough for thousands of nuclear weapons—had been blended to LEU and delivered to the United States.[70]

This HEU deal has been plagued with a series of problems, however—serious enough to interrupt blending and deliveries for months at a time. Indeed, there has never yet been a year in which as much HEU was actually blended and delivered as had been agreed for that year. These problems were largely caused by placing the deal in the hands of the United States Enrichment Corporation (USEC), which has had no profit incentive to implement it efficiently, as the large-scale imports of Russian enriched material compete with its own production, preventing it from running its plants at the most cost-effective production level.[71] The Clinton administration then compounded the error by privatizing USEC in the summer of 1998, thereby placing a critical national security initiative at the whim of the commercial market—a step that was taken even after it had become clear that changes in the uranium and enrichment markets since the initial decision to privatize made it inevitable that a privatized USEC seeking to maximize profit would have to attempt to undermine the HEU deal, and even after the administration was warned in detail of the likely security impact of privatization.[72] This

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[69] See NAS 1995, op. cit.

[70] For an overview of the HEU deal, and a discussion of the problems that beset it in its early years, see Richard Falkenrath, "The HEU Deal," Appendix C in Allison et. al., *Avoiding Nuclear Anarchy*, op. cit. For a more optimistic official view, see U.S. Enrichment Corporation, "Chronology of the Megatons to Megawatts Contract (as of January 1, 2000)" (available at http://www.usec.com/Structure/Navigation/ThirdTier/newsreleases/08-31-98.htm).

[71] The material brought in under the HEU deal represents a substantial fraction of the total U.S. market for enrichment services, greatly reducing the amount of its own production USEC requires to meet the market demand. Moreover, because of oversupply in the enrichment market, enrichment prices have fallen to the point that under the current contract, USEC is buying material from Russia at just above the price at which it can sell the material, wiping out any profit it was once making on the deal.

[72] For an overview of privatization and its early impact, see Thomas L. Neff, "Privatizing U.S. National Security: The U.S.-Russian HEU Deal at Risk," *Arms Control Today,* August/September, 1998 (available at http://www.armscontrol.org/ACT/augsep98/tnas98.htm); the earlier background can be found in depressing detail in Falkenrath, "The HEU Deal," op cit.

episode certainly ranks among the most egregious national security blunders of the Clinton team.

As predicted, USEC privatization caused another rupture in the deal, stopping deliveries for months. This impasse was temporarily resolved only after Congress, with the leadership of Senator Pete Domenici (R-NM), provided a taxpayer subsidy of $325 million to save the agreement in the fall of 1998. Even then, a final agreement that allowed deliveries to restart was not reached until March 1999, after difficult negotiations.[73]

As expected, however, that "fix" was temporary: by the summer of 1999, USEC was actively seeking to get out of the five-year contract (running to the end of 2001) it had signed with its Russian partner while still government-owned, demanding either that Russia accept prices far below those that had been agreed in the contract, or that the U.S. government give USEC a subsidy of $200 million to compensate for its claimed lost profits in continuing to implement the contract. USEC threatened to pull out of its agreement with the U.S. government to serve as the "executive agent" for the HEU purchase agreement if its demands were not met. This dispute boiled over into disagreements over delivery schedules and canisters for shipping the uranium, and by early fall, the Russian Ministry of Atomic Energy indicated that with USEC unwilling to agree on delivery schedules, it had no choice but to cease blending HEU. After an intensive round of discussions between DOE, USEC, and the Russian partners in the deal, deliveries were resumed and USEC announced on December 1, 1999, that it would continue as executive agent even though neither Russia nor DOE had agreed to USEC's demands.[74] Most analysts expect, however, that this resolution too will be temporary, and that continued U.S. government intervention will be needed as long as the deal remains solely in USEC's hands, with no competition to ensure a fair market price.

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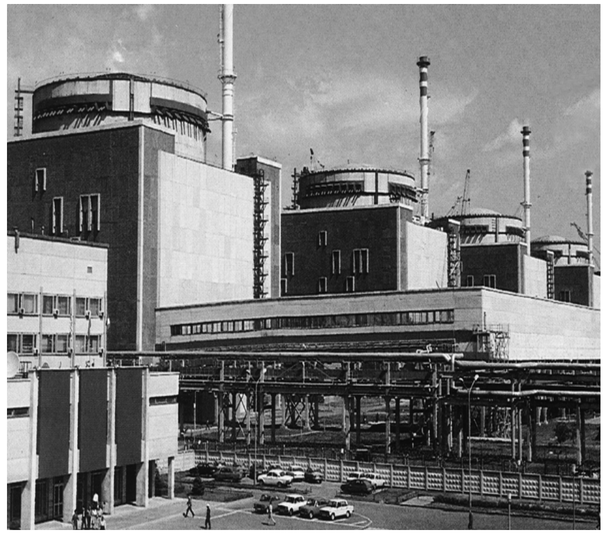
[73] As the HEU deal is currently structured, the uranium and enrichment work represented by the low-enriched uranium Russia delivers are handled separately, with different commercial arrangements. The March 1999 deal involved the United States government buying the uranium component of the material Russia had already delivered in 1997 and 1998—and agreeing to hold both that material and a substantial quantity of its own material off the market for a decade, to reduce the oversupply in the uranium market (which was caused in part by the U.S. decision to privatize USEC with a huge stockpile of uranium in its possession). Three Western companies—Cameco, Cogema, and Nukem—reached a simultaneous commercial contract with Russia giving them options to buy the uranium component from subsequent deliveries. Uranium the three companies did not choose to buy would be returned to Russia. In the end, the deal only addressed the uranium part of the HEU purchase agreement, not the enrichment part—which is more fundamental to USEC's interests as an enrichment supplier—and since all the three companies were buying were options, which they would not take up if the price declined, the uranium part of the deal was not permanently stabilized either. For a useful explication of this rather complex agreement, see "The U.S.-Russia HEU Agreement," *UI Trade Briefing*, Issue 1, London: Uranium Institute, August 1999.

[74] See "USEC to Continue as Executive Agent for Megatons to Megawatts Program," USEC press release, December 1, 1999. Unfortunately, no comprehensive account of the maneuvering that led up to that point is yet available; much of this summary account is based on interviews with U.S. government officials. For discussions of portions of it, see, for example, Michael Knapik and Ray Silver, "USEC Looking to Administration, Congress For Help, Officials Weigh Comprehensive Fix," *Nuclear Fuel*, October 18 1999, and Michael Knapik and Wayne Barber, "Glitches in HEU Deal Coloring Debate in Washington Over USEC Subsidy," November 1, 1999. The author is grateful to Thomas L. Neff (author of the first published suggestion for the HEU deal) for extensive discussions of the HEU deal and access to a number of unpublished analyses.

Indeed, USEC has continued to call for changes in the deal or U.S. subsidies for continuing in it, as its stock price plummets, its corporate credit rating declines, and it continues to lay off workers.[75]



These four VVER-1000 reactors at Balakovo are the most modern nuclear reactors in Russia, and could be modified to burn plutonium fuel in perhaps a third of their reactor cores. Existing Russian reactors can probably be modified to burn roughly two tonnes a year of weapon-grade plutonium, but doubling that rate at a later state, as called for in a draft U.S.-Russian agreement, would require shipping plutonium fuel to reactors in other countries, extensive modifications to existing Russian reactors, or disposing of some plutonium as waste. Source: PNNL

Even if it were implemented smoothly in the future, the HEU deal as it now stands certainly does not resolve all the key issues posed by excess HEU in Russia. As described in Section IV, there are strong arguments for blending and buying more HEU, and faster. The 75 tonnes blended over the six years since the deal began represents less than 7 percent of the Russian HEU stockpile; although the pace is now going to increase to 30 tonnes per year (if all goes well), a decade hence it will still be true that only about a third of the Russian HEU stockpile will have been addressed. Indeed, the entire 500-tonne deal represents less than half of Russia's total HEU stockpile. Moreover, the deal involves bulk processing and transport—steps that create new vulnerabilities to possible theft—of tens of tonnes of weapons-usable material a year, yet there have not yet been any substantial upgrades to security and accounting at the areas of facilities where the HEU is being blended and processed.

Disposition of Russia's Excess Plutonium

Still less progress has been made in dealing with Russia's excess weapons plutonium. The basic options available—use as reactor fuel or immobilization—are the same as in the United States. But Russia lacks both the money to pay for either of these options and the number of modern, safe reactors needed to burn the material rapidly as fuel. Moreover, Russia refuses to consider the immobilization option, considering the plutonium as a valuable national asset produced with thousands of man-years of labor, not something to be thrown away as waste (see "Russian Perspectives on Plutonium Disposition," p. 58). At their September 1998 summit, President Clinton and President Yeltsin signed an agreement in principle to carry out disposition in stages of fifty tonnes of plutonium on each side, and called for negotiation of a more specific and binding government-to-government agreement laying out how this would be done by the end of 1998.

[75] See, for example, Martha Hamilton, "Uranium Firm to Cut 20% of Jobs," *Washington Post*, February 4, 2000.

Budgets for Warhead and Fissile Material Control
Before and After the Expanded Threat Reduction Initiative[1]

	FY1999 (app.)	FY2000 (req.)	FY2000 (app.)	FY2001 (req.)
Preventing Theft and Smuggling				
MPC&A	$140M[2]	$145M	$150M	$172M[3]
DOE "Second Line of Defense"	$ 3M	$ 3M	$ 3M	$ 3M[4]
DOD/FBI/Customs Nuclear Smuggling	$ 4M	$ 4M	$ 5M	$ 6M [5]
Mayak Storage Facility	$ 61M	$ 64M	$ 64M	n.a.
Nuclear Warhead Security	$ 52M	$ 55M	$ 99M	n.a.
BN-350 Spent Fuel Security	$ 15M	$ 16M	$ 15M	$ 16M
Stabilizing Nuclear Custodians[6]				
Nuclear Cities Initiative	$ 15M[7]	$ 30M	$ 7M	$ 17M
Closure of Penza-19 and Avangard	--	--	--	$ 10M
IPP	$ 22M[8]	$ 30M	$ 22M	$ 22M
ISTC+STCU	$ 22M	$ 95M	$ 59M	$ 45M
CRDF	$ 10M	$ 23M	$ 15M	$ 23M
Monitoring Stockpiles and Reductions[9]				
HEU Purchase Transparency	$ 14M	$ 16M	$ 16M	$ 15M
DOE+DOD Transp. Development[10]	$ 24M	$ 26M	$ 23M	$ 28M [11]
Trilateral (U.S.-Russia-IAEA) Support[12]	$ 3M	$ 3M	$ 2M	$ 2M
Ending Further Production				
Pu Reactor Shutdown/Conversion	$ 30M	$ 20M	$ 32M	$ 32M.
Ending Civilian Pu Production	--	--	--	$ 38M
Reducing Excess Stockpiles[13]				
Plutonium Disposition	$ 28M	$ 25M	$ 30M	$ 40M
Converting Plutonium Components	$ 9M	$ 9M	$ 9M	n.a.
Add'l New Nonproliferation Initiatives				
Joint proliferation-resistance R&D	--	--	--	$ 20M
Joint waste disposal R&D	--	--	--	$ 5M
Return of HEU to Russia	--	--	--	$ 3M
Crisis Center	--	--	--	$ 2M
Total	$ 452M	$ 564M	$ 551M	$669M[14]
% change from FY99 funding	--	+25%	+22%	+48%
Total excluding science cooperation[15]	$ 398M	$ 416M	$ 455M	$579M
% change excluding science cooperation	--	+5%	+14%	+45%

[1] Compiled from budget documents for the Departments of Defense, Energy, and State, supplemented with internal budget data provided by officials of these departments. Table does not include funding for implementation of similar measures reciprocally in the United States, such as funding for the U.S. plutonium disposition program. For a detailed accounting of Congressional authorization and appropriation actions in FY2000 for programs in the Expanded Threat Reduction Initiative, see William Hoehn, *Russian Nuclear Security and the Clinton Administration's Fiscal Year 2000 Expanded Threat Reduction Initiative: A Summary of Congressional Action*, Washington DC: Russian-American Nuclear Security Advisory Council, forthcoming (March 2000); for additional information on the FY2001 request, see Matthew Bunn and William Hoehn, "The Clinton Administration's Fiscal Year 2001 Budget Requests for Nuclear Security Cooperation With Russia," Washington DC: Russian-American Nuclear Security Advisory Council, forthcoming (March 2000). All figures are rounded to the nearest million.

[2] This represents the amount actually made available to the program by DOE; Congress appropriated $12M more, but DOE shifted $4.5 million to the Initiatives for Proliferation Prevention program and $7.5 million to the Nuclear Cities Initiative.
[3] DOE's request includes $150 million in the MPC&A line-item, an additional $15 million explicitly for MPC&A as part of the $100M new "Long-Term Nonproliferation Program for Russia" and an estimated $7 million for MPC&A at the Mayak facility in the part of the new long-term program related to a cessation of reprocessing of civilian power reactor fuel at Mayak.
[4] This funding, and the FY2000 funding, is being provided by the Department of State.
[5] This program has traditionally been funded by reprogrammings from other accounts within the Department of Defense, so specific amounts are not identified in the FY2001 budget—though it may soon receive its own line-item. The FY2001 and final FY2000 figures are estimates based on interviews.
[6] With the exception of the Nuclear Cities Initiative, all of the programs in this category fund a range of activities many of which are not directly related to nuclear issues. IPP and ISTC both fund projects that employ former chemical and biological weapons scientists, as well as former missile and aerospace scientists, in addition to nuclear experts; CRDF supports civilian science in the former Soviet Union in general, and only a very small portion of its funds support work at major nuclear facilities. Thus, the inclusion of the total budgets for these programs exaggerates the total amount of funds being directed to nuclear security efforts—budget breakdowns year-by-year for each project that would make it possible to include only the nuclear portion are not consistently available.
[7] Congress provided only authorization to find funds elsewhere; these funds included $7.5 million from the MPC&A program and $7.5 million in other program's prior-year balances.
[8] This included $15 million appropriated by Congress, $4.5 million taken from the MPC&A program, and $3 million from other arms control and nonproliferation functional areas.
[9] These programs were not officially included within the Expanded Threat Reduction Initiative, but are included here for completeness.
[10] The budget for DOE's Warhead and Fissile Material Transparency program was $9.5 million in FY1999. In addition, a joint DOE-DOD Integrated Technology Plan to evaluate transparency technologies for START III, Mayak Transparency, and the Trilateral Initiative was begun in FY1999, funded at just under $20 million (with $4.85 million of that total coming from DOE's $9.5 million transparency program, and the remainder from accounts in the Defense Threat Reduction Agency and DOE's nonproliferation and verification research and development division). DOE requested $16 million for its Warhead and Fissile Material Transparency program in FY2000, but expected that the combination of those funds and contributions from DOD and elsewhere in DOE to the technology plan effort would total $26 million; in the end, the total came to just over $22.5 million (interviews). For discussion of some of these initiatives, see *Warhead and Fissile Material Transparency Program Strategic Plan*, op. cit.
[11] DOE requested $16 million for its transparency analysis and negotiations program in FY2001, but the total contributions to the overall integrated transparency technology plan will not be determined until later in fiscal 2000. This estimate is based on assuming that the contributions from outside the known account at DOE remain the same in FY2001 as they were in FY2000.
[12] While these funds support a joint effort with Russia and the IAEA to develop the procedures for placing excess nuclear material under IAEA verification, essentially all of the funds are spent in the United States, not in Russia. Additional funds spent to support IAEA verification of excess materials in the United States are not included on this chart.
[13] This does not include the one-time FY1999 Congressional add-ons of $325 million for the HEU deal and $200 million for plutonium disposition work with Russia. In addition, it includes only funds targeted to support disposition of Russian excess plutonium, not the funds intended to support disposition of U.S. excess plutonium and HEU.
[14] Although specific budget figures for FY2001 for the Mayak storage facility, warhead security projects, and conversion of warhead components are not available, the total proposed for these activities is $170 million. See Bunn and Hoehn, "The Clinton Administration's Fiscal Year 2001 Budget Requests," op. cit.
[15] As noted above, a significant portion of the funds for IPP, ISTC, and CRDF fund projects that have nothing to do with nuclear matters, and therefore a somewhat more accurate sense of the overall budget trend for nuclear material security can be found by excluding the budgets for these programs.

DOE's Proposed Long-Term Nonproliferation Initiative for Russia

In its budget request for fiscal year 2001, the Department of Energy (DOE) proposed a $100 million new "Long-Term Nonproliferation Initiative for Russia," as an additional component of the continuing Expanded Threat Reduction Initiative (ETRI). Unlike the original ETRI, the new proposal finally calls for real increases for programs to reduce the urgent security threats posed by weapons-usable nuclear materials in the former Soviet Union, including new initiatives to accomplish that objective. In effect, the new initiative would increase the total funds for programs directly related to controlling these threats by about 20 percent. The specific initiatives covered by this new proposal are urgently needed and deserve strong support—though the proposal remains far smaller than the doubling or tripling of funding for these efforts called for in this report (and substantially smaller than the amount DOE suggested at the outset of the Administration's internal budget debates).

The specific initiatives in the new proposal include:[1]

- **A halt to the accumulation of weapons-usable civilian separated plutonium.** As described elsewhere in this report, a critical part of DOE's new initiative is an effort to reach agreement with Russia on a moratorium on separating plutonium from spent fuel from civilian power reactors. Cutting off the continued piling up of ever more weapons-usable plutonium—accompanied by massive bulk-processing of plutonium in a facility without accurate accounting systems for the material in place—is an extraordinarily important effort. Toward that end, DOE proposes to provide $38 million to assist in building dry-cask storage for the spent fuel that would otherwise be reprocessed, and $7 million for further security and accounting improvements at the Mayak facility. In addition, DOE proposes to finance joint U.S.-Russian R&D on more proliferation-resistant approaches to nuclear energy (see below). DOE officials report that they have reached an oral understanding with MINATOM on such a reprocessing moratorium. Approval of the requested funding however, is likely to be essential to reaching final written agreement with MINATOM on a reprocessing halt.
- **Accelerated nuclear material security and accounting improvements.** DOE's proposal includes $15 million targeted for further MPC&A work, including funds for accelerating the small program to consolidate and blend down small stockpiles of HEU from particularly vulnerable facilities, and additional work to secure HEU naval fuel at sensitive Russian navy facilities. Both of these are urgently needed steps—though the amount of funding that would be required to move them forward as quickly as possible is substantially larger than the amount DOE proposes, particularly in the case of the consolidation and blend-down effort.

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[1] *Fact Sheet: Long-Term Nonproliferation Program for Russia,* U.S. Department of Energy, February 7, 2000, and interviews.

While negotiations since September 1998 have been much slower than expected, by the end of 1999 a draft agreement on plutonium disposition was nearly finished, and was expected to be signed in the first half of 2000. The draft agreement as it has taken shape calls for disposition of 34 tonnes of plutonium on each side in the first stage, not 50—because the U.S. excess declaration includes only 34 tonnes of relatively pure weapons-grade plutonium, and the Russian side was not willing to carry out disposition of 50 tonnes of genuine weapons-grade plutonium coming directly from dismantled weapons while the United States carried out disposition of 34 tonnes of comparable material and 18.5 tonnes of fuel-grade plutonium, reactor-grade plutonium, and plutonium in what some have called "ash and trash" (see "Enormous Excess Stockpiles—And Still Larger Remaining Military Stocks," p. 54). There is recognition in the agreement, however, that additional plutonium stockpiles may be added to the process as nuclear arms reductions continue. The agreement does not, however, address whether the long-term goal should be equal reductions or

- **Accelerated closure of weapons assembly facilities.** DOE proposes to spend $10M to help accelerate the closure of two of Russia's four nuclear weapons assembly and disassembly plants. If successful, this project could, in a short period of time, significantly reduce Russia's nuclear weapons manufacturing capacity. In addition, if agreement can be reached with Russia, some of these funds would go to establish sites for demonstrating technologies and procedures for verifying warhead dismantlement without revealing classified information—a key element of U.S. long-term nuclear arms reduction objectives.
- **R&D on proliferation-resistant nuclear energy and waste disposal.** Developing new approaches to nuclear energy that pose less of a nuclear proliferation threat serves both U.S. and Russian interests. DOE proposes to spend $20 million to finance joint R&D with Russia on such proliferation-resistant nuclear energy systems. MINATOM is eager in particular to study fuel cycles that make more efficient use of uranium resources than do typical light-water reactors on a once-through fuel cycle, but do not involve fully separating directly weapons-usable plutonium—and funding for joint work on such systems is likely to be critical to MINATOM's agreement to a reprocessing moratorium, as MINATOM sees that moratorium as only a temporary halt until improved, proliferation-resistant reprocessing technology is developed. U.S. funding for joint proliferation-resistance R&D, however, would not be made available unless the United States and Russia can reach agreement on the contentious issue of Russia's nuclear cooperation with Iran. In addition, DOE has proposed $5 million in joint R&D on disposal of nuclear wastes—a problem facing both countries, where each has data from its own past efforts that would be useful to the other's program.
- **Returning research reactor HEU to Russia.** A particularly important new initiative in DOE's proposal is an effort to begin work on returning Soviet-supplied HEU to Russia. As described elsewhere in this report, given Iraq's effort to use the HEU from its research reactor for a nuclear bomb, it is important to work to get rid of the HEU fuel in research reactors in such countries at Yugoslavia, North Korea, Libya, and Vietnam as rapidly as possible. Russia is willing to encourage these countries to shut down their research reactors or convert them to proliferation-resistant LEU fuels (being developed in Russia in another U.S.-sponsored effort), and to take the HEU they now have back to Russia, but cannot afford to pay the costs of such an effort. The $3 million DOE proposes to spend in this area is only a fraction of what is needed—enough to get initial studies and preparations underway, but not enough to actually package and ship the HEU from these facilities back to Russia.
- **A nuclear crisis center.** Finally, DOE proposes to spend $2 million on continuing operation of a joint U.S.-Russian nuclear crisis center, allowing the two sides to communicate in real time in managing any nuclear safety or security emergencies that may arise.

Each of these proposals is an important and useful initiative in its own right—but even if fully funded, they still fall well short of what would be required to reduce the security threats posed by the Cold War legacy of nuclear warheads and materials as rapidly and effectively as there are now opportunities to do so.

reductions to equal levels—a critical point for the longer-term future, given the much larger initial Russian plutonium stockpile.

Under the draft agreement, Russia's excess weapons plutonium and at least 25 tonnes of the U.S. excess weapons plutonium is to be burned in reactors as MOX. In an initial phase beginning by 2007, Russia is to carry out disposition of 2 tonnes of plutonium per year (the most that can plausibly be accomplished with modest modifications of Russia's existing reactors, as described below), while in a subsequent phase (which might involve reactors in other countries), this rate is to at least double, to the roughly 4-ton-per-rate planned for the weapon-grade portion of the U.S. program.

Under the agreement, the cost of Russian plutonium disposition is to be covered by contributions from Western countries, including the United States; if adequate funding is not forthcoming, the parties are no longer obliged to carry out the disposition of 34 tonnes of plutonium. The agreement calls for specified transparency and monitoring measures, and commitments that during the disposition period, any MOX plant built to carry out the agreement will not be used for civilian plutonium, exports of plutonium-bearing fuel will only be carried out by mutual agreement, and there will be no reprocessing of any of the resulting spent fuel or immobilization wastes.[76]

Two fundamental obstacles need to be overcome for this first-step effort to begin eliminating Russia's excess weapons plutonium to be successful. The first problem is financing: Russia has made it clear that it cannot afford to pay the cost of disposition of its excess plutonium (unknown at this time, but likely to be in the range of $1-$3 billion), but other countries have pledged only a small part of the required funds. Under Senator Domenici's leadership, the Congress put a $200 million down-payment on this cost into the fiscal 1999 budget—a move which made clear to Russia that there was a real prospect of substantial U.S. financial contributions toward the cost of disposition, and was therefore absolutely essential to Russian willingness to negotiate the draft agreement described above.[77] The Administration has requested an additional $200 million over five years in its Expanded Threat Reduction Initiative. In the spring of 1999, Japan made a pledge of $200 million for submarine decommissioning, re-employing weapons scientists, and plutonium disposition in Russia—but it is expected that only a small fraction of that amount will be for plutonium disposition (focused on part of the work of converting the BN-600 fast reactor to burn partial cores of plutonium), leaving the financing arranged to date still far less than what is needed.

Discussions of contributions to finance Russian plutonium disposition are under way under a group initiated by the Group of Eight—whose leaders pledged at the Cologne summit in 1999 to "review potential in our own resource commitments" prior to the next summit, scheduled for Okinawa in July 2000[78]—but as of early 2000, no substantial additional pledges had been made, and it remained highly uncertain whether pledges remotely sufficient to the task would be forthcoming in Okinawa.

The second major obstacle is the lack of sufficient Russian reactors to burn the Russian plutonium. If all seven of Russia's most modern light-water reactors, the VVER-1000s, and its only operational fast-neutron reactor, the BN-600, were converted to burn partial cores of MOX fuel—which may or may not be possible in the case of some of the older plants—they could burn roughly 2 tonnes of plutonium per year.[79] At that rate, even after the years required to get going, it would take 25 years—substantially longer than the remaining operational lives of these reactors—to burn the 50 tonnes of plutonium Russia has included in its formal declaration of excess, to say nothing of the

[76] Interviews. See also Holgate, "Plutonium Disposition," op. cit.

[77] This $200 million is available until expended, so it need not be spent in any particular year, and indeed very little of it has been spent to date. It will be spent to support the facilities needed to carry out the 34-tonne agreement, but will not be sufficient for that purpose; exactly which portion of the various activities envisioned would be paid for with this increment of $200 million has not yet been definitely determined.

[78] *G-8 Summit: Cologne Communiqué 1999,* Cologne, Germany, June 20, 1999 (available at http://www.state.gov/www/issues/economic/summit/99communique.html).

[79] Current thinking is that only these reactors could be modified at reasonable cost to be safe enough to burn plutonium fuels. If only the four most modern VVER-1000s could be modified to burn plutonium, and they and the BN-600 could only handle plutonium fuels in about one-third of their reactor cores, these five reactors would consume roughly 1.3 tonnes of plutonium per year. If, on the other hand, all seven VVER-1000s could handle plutonium fuels, this figure increases to approximately 2 tonnes per year.

huge quantities of civilian separated plutonium it has also committed never to use in weapons, or the even larger amounts that may become excess as disarmament proceeds. Moreover, whether it will be politically, technically, and economically feasible to modify and use such a large number of Russian plants for disposition of excess weapons plutonium remains highly uncertain. Concepts for an international consortium that would buy MOX made from Russian weapons plutonium and market it to reactors in Ukraine, Western Europe, Japan, and Canada are being considered, but no genuinely credible scheme has yet been put in place. Another possibility which is being examined is to carry out more extensive modifications on some of the Russian reactors, so as to allow them to burn MOX in larger fractions of their reactor cores; this could make it possible to achieve the goal of at least four tonnes per year specified in the draft U.S.-Russian agreement using only existing Russian reactors (two additional VVER-1000 reactors are close to completion, but whether and when MINATOM will find the funds to finish them remains uncertain).

Alternative concepts which have been proposed, but which are not currently being actively pursued, include (a) building additional reactors in Russia, such as the BN-800 fast neutron reactors MINATOM has long hoped to build, or the high-temperature gas reactors being developed in a Russian-U.S.-French-Japanese joint program (an approach criticized in U.S. studies because of the extra costs and delays involved in building new reactors); (b) shipping the excess plutonium to storage facilities outside of Russia, regardless of whether it can be used in the near term, as the quickest means to address the security threats it poses; (c) fabricating the Russian plutonium into fuel in existing European MOX fabrication plants, instead of the civilian plutonium they are currently planning to fabricate during that period; and (d) purchasing the Russian excess plutonium and shipping it to the United States for incorporation into the U.S. disposition program. Russia has made clear that it would very much prefer to build the new BN-800 reactors and use those to burn the excess weapons plutonium, but it is unlikely that the international community would provide the funds for this. Russia has also made clear that it will *not* accept any option that involves shipping the plutonium abroad in forms other than fabricated fuel.

In the meantime, the United States, France, Germany, Canada, and Japan each have programs to cooperate with Russia in analyzing, developing, and testing the technologies needed for disposition of Russia's excess weapons plutonium. The U.S. program of technical cooperation, funded at roughly $25 million per year, is by far the most extensive of these efforts, and includes efforts related to safe use of MOX fuel in Russia's VVER-1000 reactors, conversion of the BN-600 breeder reactor to a plutonium "burner" reactor that would consume more plutonium than it produces, immobilization of plutonium, stabilization of unstable forms of plutonium, and conversion of metallic plutonium from weapons into oxides suitable for use as MOX. The U.S. and Russian teams reached agreement on a technical workplan for plutonium disposition in late 1999. The French and German efforts have largely focused on initial feasibility studies followed by detailed design work on a modest-scale MOX plant suitable for supplying four of Russia's VVER-1000 reactors and the BN-600 (though the French have also funded joint work on conversion of metallic weapons plutonium to oxide). The Japanese program focuses primarily on conversion of the BN-600 reactor, while the Canadian program focuses on studies of the use of weapons plutonium as MOX in Canadian CANDU reactors.

In short, substantial programs are in place to address each of the five areas of threat outlined in Section II. These programs are making significant progress, and deserve strong support. But far more remains to be done than has yet been accomplished—and the pace of progress to date simply does not match the scale and urgency of the threat.

IV. THE NEXT WAVE: URGENTLY NEEDED NEW STEPS

Major action is urgently needed to rapidly reduce the proliferation and arms reduction risks posed by the insecure, oversized, and unmonitored nuclear stockpiles and nuclear complex in the former Soviet Union. The basic principle of an expanded program should be to provide the resources and leadership necessary to reduce these security threats as rapidly as it is practicable to do so.

Such an accelerated and expanded program should be guided by a set of strategic objectives and timetables for achieving them. A program unconstrained by resources, with sustained leadership from the highest levels of the U.S. government, should be able to achieve the following seven strategic objectives within roughly five to seven years:

- Substantially reduce the number of sites and buildings where fissile material is stored, and install effective security and accounting systems for all the remaining buildings;
- Put in place a structure of resources, incentives, and organizations needed to achieve and sustain security for all fissile material in the former Soviet Union for the long haul;
- Blend all Russian and U.S. excess HEU (potentially including far more than just the 500 tons of Russian HEU covered by the current U.S.-Russian HEU Purchase Agreement) to forms that can no longer be used in weapons;
- Begin large-scale disposition of U.S. and Russian excess plutonium, with agreements and budgets in place to cover the financing of the disposition program and provide adequate reactor and/or immobilization capacity to get the job done;
- Substantially reduce the Russian nuclear weapons complex's capacity for new weapons production, and re-employ thousands of the scientists and technicians no longer needed in that complex;
- Put in place a system of reciprocal data exchanges, monitoring, and transparent warhead dismantlement that will begin laying the basis for deep, transparent, and irreversible nuclear arms reductions; and
- Reach agreement with Russia on reducing total warhead stockpiles, and reducing fissile material stockpiles to the levels needed to support the agreed warhead levels.

Each of these objectives is ambitious. But objectives of this kind are what the security threats posed by the vast Cold War stockpiles of warheads and fissile material demand. It is possible that some of them would not be achieved within five to seven years even with substantially increased resources and sustained high-level attention. But without those critical ingredients, it is likely that none of these objectives will be achieved in a timely way, and huge security risks will remain.

New steps are needed in each of the five areas outlined in the previous section. A comprehensive strategy including specific proposals in each of these areas is detailed below. The strategy can be summarized (see table) as a six-point plan requiring the expenditure of $1–$1.5 billion a year for each of the next five years—roughly a doubling or tripling of currently planned funding for programs related to safeguarding warheads and fissile material. This would represent roughly one half of one percent of the U.S. defense budget.

Preventing Theft and Smuggling

A revised and expanded MPC&A program is urgently needed, focused on accomplishing three strategic goals as rapidly as practicable:

- *consolidating* nuclear material at fewer buildings and fewer sites;
- *upgrading* security and accounting systems at both the facility level and the national level, while providing the needed training and services to allow these systems to be effectively used; and
- *sustaining* effective security over time.

A program to reduce the proliferation risk posed by insecure materials as quickly as technology and cooperation with the former Soviet states would allow, unconstrained by funding, would require substantially larger budgets than are currently planned. Roughly $250 million per year—an increase of roughly $100 million per year over the current program budget—for roughly half a decade, while the initial consolidations and upgrades are implemented, is a conservative estimate of what is needed.[1] While the pace at which security can be improved is constrained by factors other than money—including the degree of cooperation Russia is willing to permit, the number of experienced U.S. and Russian experts available to carry out the needed programs, and the U.S. and Russian ability to manage the efforts effectively—constrained budgets should not be allowed to slow progress, as is now the case. To protect the U.S. investment, the program should be continued at a modest level—perhaps $50 million per year—for a considerable period after the initial upgrades are accomplished, to ensure that security and accounting systems are sustained and improved, and to maintain cooperation and communication concerning the state of MPC&A.

To be successful, a revised and expanded program will have to reinvigorate the sense of partnership between U.S. and Russian participants, and between DOE headquarters and the U.S. laboratories. Ultimately, while the program is being carried out primarily with U.S. funds, the materials are Russia's to protect, and thus integrating a Russian perspective in the design and implementation of all the needed programs is essential. At the same time, however, to maintain budgetary support in the United States, it is critical to focus on implementing the steps that offer the most "bang for the buck" in improving security and accounting as rapidly as practicable, and this will inevitably

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[1] No detailed analysis has yet been done of what such a funding-unconstrained program would cost; the Department of Energy should undertake such an analysis immediately. The $250 million per year estimate arises from adding three figures: planning for the originally planned $150 million budget for FY1999 made it clear that at least that amount could be effectively spent installing upgrades and providing associated training, while unpublished analyses by participants in the MPC&A program suggest that that substantial consolidation and sustainability programs might each cost $50 million per year. Some period would be needed to scale up the effort from the current $140 million a year level. Information from interviews.

An Agenda for Action: Summary of Key Proposals

Proposal	*Approximate Cost Over Five Years (est.[2])*
Expand nuclear material security and accounting program to level not constrained by funding	$1.3 billion[3]
Pay costs and financial incentives to blend all excess HEU to LEU within a few years	$1 billion[4]
Finance disposition of excess Russian plutonium	$2 billion
Help shrink Russian nuclear weapons complex, and re-employ excess scientists and technicians	$0.5 billion
Offer to finance transparent dismantlement of thousands of warheads, with reciprocity	$0.5 billion
Expand available revenue for nuclear security through spent fuel storage, HEU purchases, debt swaps, and/or lifting restraints on legitimate exports[5]	$0-$2 billion
Total:	$5-$8 billion

require some patient negotiation to bridge differences between the U.S. and Russian perspectives.[6] Key steps toward achieving each of the three strategic goals are described below.

Consolidation

Consolidation of nuclear materials is an urgent priority: protecting fewer buildings and fewer sites means that higher levels of security can be provided at lower cost over the long run. When material is removed from facilities completely, the risk of theft at those facilities is eliminated entirely. While the Russian Ministry of Defense has reduced the number of nuclear warhead storage sites from over 500 to less than 100, as discussed above, there has been very little consolidation of weapons-usable material sites. Since

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[2] These are central estimates of five-year cumulative expenditures, based on the author's judgment of total costs. Since, in many areas, substantial programs are already underway funding a portion of these costs, the *additional* costs of the proposed program compared to the already planned program would be perhaps $1-$2 billion less. Further analysis with the resources available to the government would be required to develop more precise and budget-ready estimates.

[3] Assumes an MPC&A budget increased to roughly $250 million per year, as described in the text. The *additional* cost beyond funding levels already planned would be only $500 million over five years.

[4] The actual cost of the blending would likely be substantially less than this, but this figure includes financial incentives for Russia to agree to undertake the blending as well. Of course, it is possible that even larger financial incentives would be required. The U.S. government could recoup a portion of the cost later, if the payments were in the form of pre-payments against future deliveries.

[5] See "Generating New Revenue for Nuclear Security," p. 86.

[6] For further discussion of these issues, see Bukharin, Bunn, and Luongo, *Renewing the Partnership*, op. cit.

Purchasing Vulnerable HEU Stockpiles

The United States is purchasing 500 tons of HEU from dismantled Russian nuclear weapons—which may be among the most secure HEU in the former Soviet Union. It is time to add an accelerated effort to purchase the most vulnerable HEU stocks as well.

Scattered through the former Soviet Union are nearly two dozen small, underfunded civilian nuclear research facilities possessing HEU in amounts ranging from a few kilograms to hundreds of kilograms or more.[1] Some of these are within Russia, but there are research facilities that still have weapons-usable HEU in Ukraine, Kazakhstan, Belarus, Latvia, and Uzbekistan as well. Many of these facilities no longer have the money to protect the HEU appropriately, or to do the research that once required HEU. Indeed, it was at sites like these that some of the worst desperation was observed after the August 1998 financial crisis—guards leaving their posts to forage for food, electricity being cut off because bills had not been paid, and the like.

Simply purchasing the HEU from these facilities offers an opportunity to rapidly eliminate the serious proliferation risks they pose. Many of the managers of these facilities would probably be very happy to part with their HEU in return for a rapid infusion of money for their facility and a modest amount of assistance for the facility to conduct other research not requiring HEU. Because the presence of HEU has come to be associated to some degree with status and funding for the institutes, it is likely that to get agreements to clear out the HEU from the largest possible number of facilities as rapidly as possible, integrated packages of incentives will need to be tailored to the needs of each facility.

Past efforts to purchase vulnerable HEU stockpiles, such as Project Sapphire, have taken many months of preparation and cost tens of millions of dollars each—partly because of the considerable political and technical headaches of moving material to the United States or some other country outside the former Soviet Union. A faster, simpler, and cheaper approach for a broader purchase program would be to purchase the HEU and have it blended to proliferation-resistant LEU within Russia—either at the facilities now blending HEU on a large scale for the HEU purchase agreement, or at other facilities that have capabilities for small-scale blending of specialty materials like these HEU reactor fuels, such as the Luch Production Association at Podolsk, near Moscow, and the Institute of Atomic Reactors in Dmitrovgrad. Indeed, as described in the text, the MPC&A program has initiated an initial "pilot" program in which the United States pays Russia to bring HEU from potentially vulnerable sites and blend it down at Luch and Dmitrovgrad. The United States pays Luch and Dmitrovgrad for the blended LEU, and these blending facilities and MINATOM are responsible for working out arrangements with the sites from which the HEU is shipped. In its FY2001 budget request, DOE proposed to increase the funding level for this effort, to make it possible in principle to remove material from as many as 2 facilities per year over the next several years.

late 1998, however, DOE has begun placing increased emphasis on consolidation, and in the aftermath of the August 1998 financial crisis, MINATOM has recognized the need to consolidate its complex to reduce costs, and a significant cooperative consolidation effort is now planned. This effort will focus on both consolidating material at large sites in a smaller number of buildings and areas within the site, and removing material entirely from some smaller sites. While such an effort will greatly reduce long-run costs, it will involve significant short-run costs for preparing and transporting material, preparing facilities to receive it, blending it to LEU in some cases, and the like. Many sites—or even individual research areas within sites—are likely to be reluctant to give up the HEU or plutonium they have in stock, given this material's present and historic association with high-level nuclear research; in many cases, financial incentives are likely to be needed. A consolidation program should include:

- Financing for preparing and transporting nuclear material, and rapidly providing secure storage facilities to which it could be shipped;

The time has come to drastically expand and accelerate this effort, with the goal of getting all of the HEU out of as many vulnerable facilities in the former Soviet Union as possible within a few years. This includes both facilities in Russia and in the non-Russian states. Moreover, there are HEU-fueled research reactors supplied by the Soviet Union in countries ranging from Yugoslavia to North Korea to Libya. Given the example of Iraq's "crash" nuclear weapons program planning to use HEU from its HEU-fueled research reactor—and concern over Yugoslavia's stocks in the aftermath of the recent air campaign—extremely high priority should be given to getting this material out of these countries as soon as possible. In its FY2001 budget request, DOE included $3 million to fund initial work toward a Russian HEU fuel take-back program to bring this material back to Russia. But that is not enough to actually fund the transport of this material back to Russia, or to provide the needed incentives to these facilities to let it go; a substantially increased funding level, in the range of a few tens of millions of dollars a year until the job is accomplished, is an urgently needed nonproliferation investment.[2]

The total amount of HEU at the smallest and most desperate former Soviet facilities where a purchase would be most urgent is probably less than two tons. The amounts at the facilities outside the former Soviet Union are measured only in tens of kilograms. If the price negotiated were similar to the $24 million-a-ton price originally negotiated for the HEU purchase agreement, buying all of these stocks would cost in the range of $50 million. Conceivably, other costs relating to transport, blending, and the like, and additional assistance for these facilities to pursue other research, could double this cost—but ensuring effective security at these many facilities over the long term would inevitably cost still more, and could never provide absolute assurance that thefts would be prevented. One hundred million would be a very small price to pay for permanently eliminating the theft risk at many of the most vulnerable facilities in the former Soviet Union, and the risks that the material in non-Soviet states would be used in weapons.

This concept has been recommended before—indeed, a 1997 National Research Council study recommended seeking to purchase and eliminate every former Soviet stockpile of HEU outside of Russia.[3] The time to act is now—no one can know how long the world has before some of this HEU might be stolen or diverted to a weapons program. While the Administration's recent request is a useful first step, Congress should step in and direct DOE to launch a greatly accelerated and expanded purchase initiative, and provide the funds to do so.

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[1] Most of these facilities are listed under the categories "Reactor-Type Facilities" and "NIS and the Baltics", in *MPC&A Strategic Plan*, op. cit., p. 17.

[2] During the course of 1999, initial discussions of the possibility of U.S. funding for such a Russian HEU-fuel take-back program got underway. For one account of IAEA discussions in this area, see Anne MacLachlan, "IAEA Hopes Meeting Will Lead to Solution for 'Orphan' Russian-Origin Fuel," *Nuclear Fuel*, October 4, 1999.

[3] *Proliferation Concerns: Assessing U.S. Efforts to Help Contain Nuclear and Other Dangerous Materials and Technologies in the Former Soviet Union*, op. cit.

- An intensive program to purchase small, vulnerable HEU stockpiles that exist at small research reactors throughout the former Soviet Union (see "Purchasing Vulnerable HEU Stockpiles," p. 78);
- Increased financing to help HEU-fueled research reactors and critical assemblies shift to using LEU fuels (joint development of such fuels for Soviet-designed research reactors is already underway);
- Financing to help some facilities shift away from research requiring either HEU or LEU, or to close facilities completely and provide alternative employment for their workers; and
- Extensive briefings for senior MINATOM officials and site managers on the dramatic savings in safeguards and security costs that are being achieved through consolidation in the United States.

Several approaches to rapidly providing appropriate secure storage space for consolidated material can be envisioned. Modest stockpiles of HEU could be shipped to facilities with the capacity to take it out of fuel elements and blend it to proliferation-resistant LEU (such as the Luch Production Association in Podolsk—also the site at which some of the most impressive progress in intra-site consolidation has been accomplished—and the Institute of Atomic Reactors at Dmitrovgrad). Where storage buildings with effective security and accounting systems and available space already exist, these could be used. Moreover, technology exists for rapidly deployable secure storage facilities (developed to support deployment of military forces equipped with nuclear weapons), and these types of facilities could be put in place within weeks or months, should a major effort be made to do so. Some such facilities have already been used. Alternatively, some facilities in the Russian complex have large empty spaces in secure areas, where additional storage facilities could be built quickly and cheaply.[7] Finally, the current legislative restriction limiting the fissile material storage facility at Mayak to hold only materials from weapons could be modified—at least for a portion of the facility—allowing that facility, when completed, to store vulnerable weapons-usable material even if it does not come from dismantled weapons.

Upgrades

Installing effective security and accounting systems has been the central focus of the MPC&A program to date. A vast amount of work remains to be done—even if the consolidation effort is extremely successful. In many cases, a greater emphasis is needed on quickly implementing simple, low-cost steps—bricking over windows, piling rocks in front of doors—allowing time later for follow-up with more sophisticated (and expensive) approaches. At the same time, however, the initial emphasis on such physical protection upgrades has to be complemented with increased emphasis on improving material accounting and control. As a first step, the United States should work with Russia to put in place a program in which Russia would immediately identify, count, tag, and seal all containers and items with weapons-usable nuclear material throughout the Russian nuclear complex, creating at least a comprehensive record of all the materials that exist; the slower and more expensive process of performing actual measurements of the nuclear material in those myriad containers and items can proceed in parallel. (Russian secrecy concerns will make it impossible for the United States to have full access to this comprehensive record; the key is for Russia to have an accurate record of all its own materials.) Redoubled support is also needed for getting an effective *national* accounting system in place as rapidly as possible.

Finally, it is critical to remember that the job is not over when the initial upgrades are declared "complete": not only must the security afforded by the initial upgrades be maintained, but further improvements are inevitably going to be needed to offer effective security at most of these sites. Essentially none of the sites declared completed so far would meet the MPC&A standards to be granted a license to operate in the United States;

[7] See, for example, the discussion of the football-field sized concrete-lined underground facility at Krasnoyarsk-26, once intended for an additional reprocessing area, in Bunn and Holdren, "Managing Military Uranium and Plutonium," op. cit.

virtually all are still potentially vulnerable to a well-placed and knowledgeable insider working with a small group of outsiders. [8]

Hence, while DOE will probably continue to regularly hold "commissioning" ceremonies when the initial upgrades at a site are completed, these ceremonies should not be taken as the end of the job, by any means. The past policy of installing initial upgrades and essentially walking away is already being reversed, which is a welcome development; but it is important to ensure that this policy is reversed for *all* the sites with proliferation-sensitive quantities of plutonium and HEU in the former Soviet Union, including the non-Russian sites whose support has been passed from the MPC&A program to DOE's International Safeguards program. These non-Russian sites should also be a key focus of consolidation efforts.[9]

Sustainable security

Installing modern equipment will not provide a long-term security benefit if that equipment is not operated, maintained, and improved over time; if the people guarding the material and using the equipment are unpaid, untrained, and have no real incentives for good performance; and if there is no "safeguards culture" in which everyone understands that no corners can be cut when it comes to security and accounting for nuclear material. Foreign financial assistance cannot continue indefinitely, and Russian officials and facility managers will ultimately have to be convinced to allocate their own scarce resources to these tasks. The problem of how to move from installing equipment to actually achieving sustainable long-term security is absolutely central to the MPC&A program's long-term success, but is by far the most difficult intellectual and policy challenge facing the program. The sustainability efforts being undertaken so far within the MPC&A program,[10] focused primarily on ensuring that spare parts and maintenance services are available to maintain equipment, procedures are in place to use it effectively, and people are trained to use these systems and procedures, are absolutely necessary, but are not likely to be sufficient. Achieving sustainable long-term security will require changes in ingrained habits, ways of thinking, and priorities among thousands of people in the former Soviet Union, from President Putin down to workers on individual processing lines handling nuclear material. Those changes will have to come from those individuals concluding that such changes are in their interests and the interests of their facilities, organizations, and countries; exactly how the United States and other international partners can best encourage such changes remains open to debate.[11] Further

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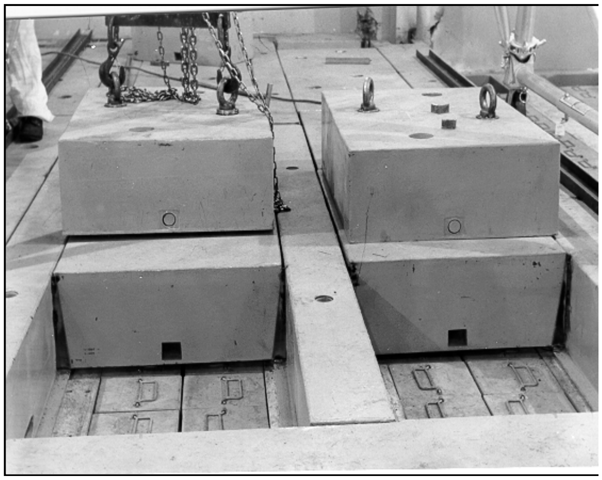
[8] Interviews with U.S. and Russian MPC&A program participants.

[9] Although all of the non-Russian facilities "completed" in the MPC&A program have been handed over to DOE's International Safeguards program, that division simply did not have the resources to seriously support further upgrades, or even sustainability measures for the existing systems. As one DOE MPC&A official put it, "our program has walked away." DOE is now considering providing additional funding to sustain upgrades at these sites—a much-needed step. Information from interviews.

[10] For descriptions, see Smarto et al., "MPC&A Site Operations and Sustainability," op. cit.; and Haase et. al., "Material Protection, Control, and Accountancy (MPC&A) Sustainability," op. cit.

[11] For a particularly useful discussion of the impediments to sustainability and steps the United States could take to overcome them, see Potter and Wehling, "Sustainable Nuclear Material Security in Russia," op. cit. For other useful discussions of the challenges of MPC&A sustainability, see, for example, James E. Doyle



These enormous concrete blocks, with interlocking steel bars, have been intalled with U.S. assistance to protect tons of plutonium beneath them from theft, at the Mayak plant in Ozersk. The MPC&A program should be given the funding and personnel resources to accomplish the mission of reducing the proliferation risk posed by insecure nuclear material as rapidly as technology and cooperation with the former Soviet states will allow. Source: DOE

complicating the policy challenge is the inevitable problem of balancing near-term upgrade measures that are urgently needed to address immediate risks of theft with long-term measures needed to build a sustainable base for the future.

What is needed is to increase the former Soviet states' *sustainable capacity* to manage nuclear materials securely, and convince them to use that capacity for this purpose. Unfortunately, experience with U.S. and international "capacity-building" programs—designed to improve recipient states' abilities to carry out tasks ranging from tax collection to providing public health services—is littered with programs that had little or no long-term benefit because they focused only on providing the technical equipment and training needed to carry out the specific task at hand (as the MPC&A program has generally done to date). For lasting benefit, experience suggests that broader problems such as the authority, resources, and organization of the institutions carrying out the task, their effectiveness in hiring and retaining qualified personnel and providing incentives for good performance, the communications among the relevant players working on the task, the presence or absence of mechanisms for regular assessment and critique of performance, and the like must also be addressed. Yet these broader issues are frequently seen as being "beyond the scope" of the assistance program, as they generally have been in the case of MPC&A.[12]

Today, facilities in the former Soviet states lack both the resources (money, appropriate equipment, appropriately trained personnel, appropriately functioning

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and Stephen V. Mladineo, "Assessing the Development of a Modern Safeguards Culture in the NIS," *Nonproliferation Review*, Winter 1998; Oleg Bukharin, *Achieving Safeguards Sustainability in Russia*, Princeton, NJ: Center for Energy and Environmental Studies, Princeton University, Report No. 305, March 1998; Perry, "From Triage to Long-Term Care," op. cit.; and Perry, "Securing Russian Nuclear Materials," op. cit.

[12] In general, there is much to be learned for the MPC&A program from other experiences in providing assistance to build a state's capacity to carry out particular government functions. The necessary systematic program of reform requires a thorough understanding of how the system whose capacity is to be built actually functions, which the MPC&A program and related efforts are just beginning to have. See Merilee S. Grindle, ed.: *Getting Good Government: Capacity Building in the Public Sectors of Developing Countries,* Cambridge, MA: Harvard Studies in International Development, Harvard University Press, 1997. For a provocative application of these lessons to the problems of nuclear material management in the former Soviet Union, see Stacy VanDeveer, "Cooperative Security and Capacity Building in the Former Soviet Union," Cambridge, MA: Managing the Atom Project Discussion Paper, Harvard University, forthcoming.

organizational structures, etc.) needed for effective security and accounting for nuclear material over the long haul, and the incentives to use what resources they have for this purpose. Spending on safeguards and security creates no additional products or revenues ("safeguards don't make kilowatts," as the saying goes), so in the absence of effective regulation imposing stringent security and accounting requirements, facility managers in the former Soviet Union facing desperate budget crises have every incentive to skimp on providing the needed funding for effective MPC&A. Beyond the individual facilities is an overall context of dysfunctional governments, depressed economies, rampant crime and corruption, and modest high-level attention devoted to MPC&A, all of which makes sustainable security far more difficult to achieve.

An expanded MPC&A sustainability effort should focus on three key areas: resources, incentives, and organizations.

SUSTAINABILITY RESOURCES. The United States should:

- Expand and plan for funding of "emergency measures" where needed—funding to keep guards on the job, keep security systems running temporarily, provide backup electricity supplies, and the like—as DOE did on a small scale in the winter and spring of 1998-1999.
- Finance the first 2-3 years of operations and maintenance of systems installed with U.S. assistance, as an initial settling-in period, with work during that period to reach firm commitments that Russia will pay to keep the systems operational after that.[13]
- Put increased reliance on indigenous personnel and firms to design, build, operate, upgrade, and operate MPC&A systems, building up the indigenous capacities to carry out these missions in the former Soviet states. In particular, the work of designing and building MPC&A systems at individual sites could increasingly be shifted to Russian firms (perhaps initially capitalized with U.S. funds if appropriate firms do not yet exist), with continued oversight by experts from the United States and in-depth cooperation between the firms and the individual sites—increasing consistency in the approaches taken at different sites, increasing indigenous capacity, and reducing costs for and burdens on U.S. personnel.[14]
- Fund the establishment and use of Russian teams to carry out realistic tests of both outsider and insider threats at Russian facilities—with wide dissemination of test results and lessons learned, and funding for fixing problems identified.[15]

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[13] DOE is currently working to ensure that installed systems have "extended warranties," and that adequate servicing capabilities and supplies of spare parts are available, but the proposal to simply pay for the full cost of operations and maintenance during the initial settling in period would expand this approach substantially.

[14] The author is grateful to Christopher Paine of the Natural Resources Defense Council for this suggestion. A Russian team from the Kurchatov Institute has already played a central role of this kind in the program to upgrade MPC&A for Russian Navy facilities, and the MPC&A groups at Sarov and Snezhinsk are beginning to play roles in working with other sites in their areas as well.

[15] Realistic testing is critically important, as the performance of a system in the real world is almost always different from its performance on paper. Moreover, in the U.S. system spectacular failures in realistic tests have proven to be an excellent mechanism for convincing high-level officials that more funding for security really was required. See discussion of the importance of performance testing in Bukharin, Bunn, and Luongo, *Renewing the Partnership,* op. cit.

- Help finance transition costs (recruitment, training, equipment, and the like) for a shift to more professional guard forces for nuclear material—either highly trained officer-dominated forces comparable to those that guard nuclear weapons, or (at least at civilian facilities) commercial firms such as those that guard Russian banks, or nuclear facilities in the United States.[16]
- Finance expanded training programs designed to build the cadre of qualified MPC&A personnel, including regular training at individual sites as well as the existing national training effort, with a focus not only on technical MPC&A but also on the critical importance to Russia and the world of preventing the spread of nuclear weapons, and the key role of effective MPC&A in that effort.
- Explore possible new revenue streams that could finance robust security and accounting program for nuclear material in the former Soviet Union after international assistance (see "Generating New Revenue for Nuclear Security," p. 86).

SUSTAINABILITY INCENTIVES. Here the appropriate goal has been aptly explained by others: "everyone involved in MPC&A planning, implementation, and oversight must know what they should do, receive rewards for doing it correctly, and expect penalties for doing it poorly or not at all."[17] Toward that end, the United States should:

- Put nuclear security and accounting at the top of the U.S.-FSU nonproliferation agenda, as a fundamental requirement for preventing the spread of nuclear weapons, which all states handling weapons-usable nuclear material must meet. This issue should be accorded an importance at least comparable to that of ratification of arms control treaties and enforcement of effective export controls. The United States should make clear that this is a fundamental requirement for improved nuclear relations, something to be emphasized at every level on every occasion until the problem is adequately addressed (as is now done with issues such as cooperation with Iran, to take one example)—and work with other leading nuclear powers to convince them to take a similar approach.
- Increase the priority devoted to strengthening regulation of MPC&A. A realistic prospect of being fined or shut down if MPC&A did not meet stringent standards would create a major incentive for facility managers to invest scarce resources in

[16] Currently there is an ongoing transition in Russia in the opposite direction: to reduce costs at some sites, guard forces from the Ministry of Interior are being replaced with private guards that are regarded as being much less capable. See, for example, First Deputy Minister of Atomic Energy Valentin Ivanov, "Status and Future Role of Nuclear Material Safety Within MINATOM's System," remarks presented at Global '99: Nuclear Technology— Bridging the Millenia, Jackson Hole, Wyoming, 30 August–2 September 1999. Ivanov's prepared text remarks that "due to insufficient funding, a significant number of the guards from the Ministry of Internal Affairs [were] replaced by institutional guards, whose proficiency compares badly to that of the guards from the Ministry of Internal Affairs." Similarly, Alexander Dmitriev, deputy chairman of the Russian nuclear regulatory agency, told Duma hearings in 1996 that the replacement of troops with "security personnel not affiliated with any ministry or government agency," or even the elimination of guard forces, leaving "no security whatsoever," was becoming "quite widespread," and warned that "there's simply no comparison between a real armed security officer and some guy of ours who occasionally gets called out to the shooting range to take a couple of shots." See "We Cannot Preclude the Possibility of Nuclear Materials Theft," op. cit.

[17] Potter and Wehling, "Sustainable Nuclear Material Security in Russia," op. cit.

ensuring adequate security and accounting.[18] The weaknesses of the regulatory organizations in the former Soviet states require a redoubled effort in regulatory support, including working with the highest levels of the governments of these states to ensure that adequate resources and authority are devoted to regulation, assistance in drafting and implementing appropriate regulations and rules, provision of training and equipment to regulatory bodies, and helping them with organizational reform (see below). MPC&A regulatory support programs need to be beefed up with additional funding and personnel, a new sense of strategic mission, and new ideas, focusing not only on Gostatomnadzor (the Russian independent nuclear regulatory agency) but also on the Ministry of Defense regulatory body that regulates military-related facilities, and on internal self-regulation within MINATOM. In particular, DOE should provide the U.S. Nuclear Regulatory Commission with the funding it needs to continue and expand its regulatory support work in the former Soviet Union.

- Write requirements for MPC&A operations and maintenance, and realistic testing, into MPC&A contracts with facilities, with incentives written into the contracts to fulfill these commitments.
- Give preference to facilities with good MPC&A in all U.S. government contracts, and use the leverage provided by such contracts to pursue MPC&A objectives. Over time, facility managers in the former Soviet Union should come to understand that excellent MPC&A is a basic "price of admission" for doing business with the United States, just as refraining from transfers of sensitive technology to potential proliferators is—and the United States should work with other leading nations to convince them to take the same approach. At the same time, the United States should seek to use the considerable leverage that funds flowing to Russian facilities from U.S. programs provide to seek additional MPC&A progress—for example, using the fact that some large Russian facilities receive most of their cash income from the HEU deal to convince them cooperate in ensuring stringent standards of security and accounting for their nuclear material.[19]
- Make achievement of high standards of MPC&A a prerequisite for U.S. support for new efforts involving bulk processing or transport of fissile material, which would otherwise increase, rather than decrease, the risks of theft and proliferation. At the same time, the United States should place high priority on working with Russia to upgrade MPC&A for those bulk processing and transport programs that are already under way with U.S. support, such as the HEU deal.
- Consciously attempt to identify and support individuals at facilities and within organizations who are working to change their institution's approach to MPC&A for the better—known in the managerial literature as "change agents."[20]

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[18] For more on the importance of MPC&A regulation, see Morris et al., "Creating the Regulatory Base for MPC&A in the Russian Federation," op. cit.

[19] Remarkably, although some of the Russian facilities that receive most of their total income from the HEU deal have been among the least cooperative with the MPC&A program, the United States has never sought to link the two.

[20] For a useful discussion of the essential role of such indigenous "change agents" in changing how an organization deals with MPC&A, see Margaret A. Barnham, Charles F. Sanders, and Thomas A. Gafford, "Providing Technical Assistance for the Development of MPC&A Systems," in *Proceedings of the Institute of Nuclear Materials Management, 40th Annual Meeting,* Phoenix, AZ, July 25-29, 1999.

Generating New Revenue for Nuclear Security

To date, essentially all of the funding for nuclear security in the former Soviet Union has come from government budgets—either the governments of the former Soviet states or foreign governments (mainly the United States) providing assistance. This is likely to continue to be the dominant source of funding for these activities in the future as well. But given the substantial cost of many of the nonproliferation and arms reduction tasks that are urgently needed, the desperate budget situation facing many of the former Soviet states, and the increasing "donor fatigue" among the states providing assistance, it is critically important to find new sources of revenue that could help pay for key programs in the near term, and help the former Soviet states afford the cost of maintaining effective security for all their nuclear material over the long haul. Such additional revenue sources could also help pay for other critical problems posed by the former Soviet Union's Cold War nuclear legacies, such as the huge cost of cleaning up the deadly radioactive contamination at Russia's nuclear sites (a job that is costing $6 billion a year in the United States' smaller and less contaminated nuclear complex).

Spent Fuel Storage. A variety of approaches have been proposed in which Russia would establish an international storage facility for spent nuclear fuel from a variety of countries, and some portion of the profit would be set aside for purposes ranging from security for nuclear material to disposition of excess plutonium to defense conversion in the nuclear cities, to nuclear cleanup. (This differs substantially from MINATOM's proposed approach, in which the profit would be set aside to build and operate a large reprocessing plant.) One of these concepts, put forward by a U.S. entity known as the Nonproliferation Trust, involving a large-scale spent fuel storage facility with over $10 billion in projected revenue to be devoted to various nuclear security and cleanup projects, has reached the point of detailed discussions of actual contracts.[1] The U.S. and Russian governments have established a joint panel chaired by Undersecretary of Energy Ernest Moniz and First Deputy Minister of Atomic Energy Valentin Ivanov to explore such approaches. The income from spent fuel storage should be sufficient to ensure that the storage would be safe and effectively safeguarded, so that the stored spent fuel itself would not contribute significantly to the proliferation or safety hazards posed by nuclear material in Russia. While concepts of this kind have significant support from some sectors of both the U.S. and Russian governments, implementing them would require (a) modifying Russian environmental laws to allow importing spent fuel for storage or disposal in Russia, (b) a U.S.-Russian agreement to permit spent fuel over which the United States has consent rights (the majority of the world's spent fuel, even outside the United States) to be shipped to Russia, an agreement that is likely to be difficult to reach because of the U.S.-Russian disagreement over Russian nuclear cooperation with Iran; (c) convincing the Russian public to accept such a scheme and allow it to be implemented; and (d) convincing the foreign utilities whose spent fuel would be stored of the credibility and legitimacy of the enterprise. As an alternative, part of the revenues from an international storage site or repository somewhere else might be directed to nuclear security in Russia, as has been suggested by the Pangea group, which is hoping to develop such facilities in Australia and possibly other countries as well.[2]

Additional HEU Sales. As suggested in the text, the United States should seek to buy additional quantities of excess Russian HEU, above and beyond the 500 tons it is currently purchasing. As part of such an additional purchase, the United States should require that a substantial fraction of the

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[1] Non-Proliferation Trust, Inc., *Long-Term Fissile Materials Safeguards and Security Project: Agreement*, Draft, May 5, 1999. For a somewhat similar concept limited to funding disposition of excess weapons plutonium, see Matthew Bunn, Neil J. Numark, and Tatsujiro Suzuki, *A Japanese-Russian Agreement to Establish a Nuclear Facility for MOX Fabrication and Spent Fuel Storage in the Russian Far East,* BCSIA Discussion Paper 98-25, Cambridge, MA: Kennedy School of Government, November 1998.

[2] For a discussion of the benefits, risks, and obstacles to such proposals, see Atsuyuki Suzuki (chair), "An International Spent Fuel Facility and the Russian Nuclear Complex," in Nunn, *Managing the Global Nuclear Materials Threat*, op. cit.

proceeds be spent on specified nuclear security purposes—ensuring nuclear guards and workers are paid, operating and maintaining security and accounting systems, and the like. (If the idea is presented carefully, MINATOM may be favorably disposed to agree to such a requirement, as it would help MINATOM ensure that the funds stay within MINATOM, rather than going to the rest of the Russian government.) While confirming that the funds were spent as agreed would be an issue, there are past precedents of U.S.-Russian agreements with similar requirements. Conceivably, such revenue could even be deposited in a separate fund with auditable accounts. If Russia agreed to spend half the proceeds from the purchase of an additional 50 tons of HEU on nuclear security, this would make available some $500 million for these purposes.

A "Debt for Security" Swap. Russia is heavily burdened with foreign debt. Some restructuring of that debt is likely to be essential to economic recovery. In many less developed countries, foreign governments or organizations have negotiated "debt-for-nature" or "debt-for-environment" swaps, in which either a specified area of land is set aside as protected area, or a certain quantity of money is set aside in a fund for environmental purposes, in return for forgiveness of a certain quantity of debt. Some of these have already been successful in the former Communist states. For example, in 1991 the creditor nations of the Club of Paris agreed to a substantial debt-for-environment swap with Poland, in which a portion of Poland's debt was cancelled, and in return, Poland made contributions to a newly established independent foundation, the Ecofund, so that the expenditure of the money on the agreed environmental purposes could be easily verified. Under current debt swap agreements with the United States, France, Switzerland, Italy, and Sweden, the Ecofund is managing $545 million in funds to be spent over the 1992-2010 period.[3] A similar approach could be taken for nuclear security, with a certain portion of Russian debt being forgiven in return for Russia agreeing to set aside funds for nuclear security into a similar independent fund. As with past debt-for-environment swaps, the amount of money to be placed into the fund each year would be less than the payments due on the forgiven debt, and would be paid in local currency rather than hard currency, increasing Russia's ability to pay. If Western governments were willing to forgive a substantial quantity of Russian debt, this could potentially provide a large enough revenue stream to support the hundreds of millions of dollars per year that it will ultimately cost Russia to ensure high levels of security and accounting for all of its nuclear weapons and fissile material. Such an initiative should be included in the current international discussions of Russia's foreign debt.

Nuclear Exports Within Proliferation Constraints. Much of the revenue the Russian Ministry of Atomic Energy now receives comes from exports of nuclear material, services, and technology, with MINATOM officials estimating that their total exports now amount to over $2 billion per year. (The division of this revenue between MINATOM and the Russian central government is not well understood outside Russia.) At the moment, however, because the United States and other Western countries have imposed stringent trade restraints on Russian exports to their markets, and Western firms dominate many of the markets in states with sound nonproliferation credentials, the growth of MINATOM's export income is sharply constrained, and much of the current income derives from exports to nations of proliferation concern that have been shunned by Western suppliers, such as Iran and India. It would be highly desirable for Western countries to take a number of steps to reduce the barriers to expanded Russian exports to markets with good nonproliferation credentials, in return for specific commitments from MINATOM to apply particular fractions of the resulting revenue to identified nuclear security endeavors. These steps would include: (a) easing trade restrictions on Russian uranium and enrichment exports, (b) encouraging an expansion of Russian fuel fabrication service exports, and (c) eventual joint design of a new generation of safer, more proliferation-resistant reactors (such as the current Russian-Japanese-French-U.S. cooperation to develop a new high-temperature gas-cooled reactor). All of these would be sensitive, as every piece of market share Russia gains would presumably be lost by a Western supplier. Given the limited nuclear market and the stiff competition for it, MINATOM's vision of exporting a new generation of simple, cheap reactors to countries all over the world is not likely to be realized. But there remain promising opportunities for action to unlock additional export revenues that could be applied to strengthening nuclear security.

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[3] See, for example, the Ecofund's web page, at http://www.ekofundsz.org.pl/eng/index-us.htm

SUSTAINABILITY ORGANIZATION. The United States should work with Russia and the other former Soviet states on a systemic program of reform of the organizations involved in MPC&A, designed to ensure that:

- Each facility with weapons-usable nuclear material has a designated office for MPC&A, with appropriate personnel and authority;
- Each national institution that controls facilities with weapons-usable nuclear material has institutional procedures and regulations for managing this material, and a designated office for MPC&A, with appropriate personnel and authority;
- The facility offices communicate appropriately with each other, and with the national authorities;
- There are clear and authoritative laws and regulations in place requiring MPC&A measures which, if complied with in their entirety, would ensure an effective system;
- The regulatory authorities have the authority, independence, personnel, equipment, and procedures required to carry out effective MPC&A regulation, including the authority to impose fines or close facilities for failure to comply with MPC&A regulations;
- There are recruitment, compensation, promotion, and training procedures in place to ensure that highly qualified people are available for all aspects of MPC&A, and have incentives for good performance; and
- There are effective mechanisms in place for interagency coordination, joint action, and dispute resolution on MPC&A issues.

These are obviously long-term goals, which must be approached incrementally, and working with a foreign government on such organization issues is far more challenging than simply providing equipment and training. But these issues are critically important to sustainability. As a first step, DOE should fund a study by non-governmental or laboratory experts to consider what measures toward these ends are most needed and what such programs might cost.

At the same time, governments rarely carry out their functions as well as they might without close oversight. In the U.S. case, embarrassing investigations by journalists, non-government advocates, and the Congress provided a major part of the impetus for substantial security improvements during the 1970s and 1980s. U.S. non-governmental organizations—perhaps with some funding from DOE—can play a critically important role in fostering the growth of non-government organizations involved in these issues in the former Soviet states, and encouraging journalists and legislators in these states to play an active role in monitoring what is being done and lobbying for change when that is necessary.[21]

NUCLEAR SMUGGLING

While the consolidation, security, and accounting measures described above are the highest priority parts of a program to reduce the risk of potential nuclear theft, new

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[21] Under the direction of William Potter, the Center for Nonproliferation Studies at the Monterey Institute of International Studies has already done exemplary work in this area, as have several U.S. foundations, supporting efforts such as the Russian journal *Yaderny Kontrol* (Nuclear Control), but there is certainly more that can and should be done.

measures are also needed to interdict nuclear smuggling—the "second line of defense" if nuclear materials are stolen. What is most needed now is a well-funded strategic plan integrating the various U.S. and international anti-smuggling efforts, specifying what organizations in what countries should have what capabilities by when, and what resources will be needed to accomplish that objective. It will not be possible to accomplish everything that might be done at once. Hence, there should be an in-depth examination of where the greatest weaknesses and the highest leverage points for improving the response to nuclear smuggling lie. In particular, goals should include:

- *Establishing trained police units to deal with nuclear smuggling.* Each key country should have at least a small unit of law enforcement officers capable of investigating nuclear smuggling cases. These officers would have the training and equipment to distinguish between, for example, intensely radioactive cesium and weapon-usable plutonium, or between relatively innocuous low-enriched uranium and weapon-usable highly-enriched uranium. Other forces that might encounter a nuclear smuggling incident—police, intelligence, border patrols, customs—should be made aware of the existence of this specialized unit, and how and when to contact it. Key states could be helped to establish, train, and equip such units relatively rapidly, for a cost in the range of a few millions to a few tens of millions of dollars.
- *Increased intelligence and police cooperation.* All of the principal successes in finding and recovering stolen weapons-usable nuclear materials have been the result of informers and sting operations—which is to say, they have resulted from the efforts of police, intelligence, and "special services." Some nuclear materials have been seized in random searches carried out by border guards and customs agents, but these have been relatively inconsequential in comparison. The lesson is the importance of intelligence, of knowing where to look. Therefore, despite the enormous hurdles faced by any effort to increase cooperation and exchange of information related to sensitive investigations and sources, increased police and intelligence cooperation across borders must be a top priority. For example, the FBI's office in Moscow should include a cadre of experts on nuclear smuggling, who could cooperate with Russian counterparts.
- *Training and equipping border patrols and customs*. The immense volume of traffic that crosses international borders every day, and the vast and sparsely-populated length of the borders between some of the key countries, makes the task of interdicting nuclear materials as they cross international borders extremely difficult—as evidenced by the massive flows of drugs and other contraband that governments have so far been unable to stop. Nevertheless, border guards and customs agencies in each of the key potential source states and transit states should be provided with sufficient equipment and trained personnel to monitor at the least the main border crossings and international exit/entry points. The steps taken in this direction so far have covered only a few border points in a few states, with little long-term strategic planning of what capabilities should be in what places by what time. For a cost in the range of $10 million, for example, all of the 22 identified key border points in Russia could be appropriately equipped and customs officials trained, in only a year or two.[22]

[22] Information from interviews.

- *Providing regularized mechanisms for forensic analysis of seized nuclear material.* For several years, an international team of experts has been reviewing methods for forensic analysis of seized packages containing nuclear material, analysis that can help identify where the material came from and where it has been since. Only a few labs in the world have the right capabilities for all the various analyses that may be critical. It would be useful to set up more regularized procedures for transferring seized material across international boundaries when necessary for effective forensic analysis.

Stabilizing Nuclear Custodians

To reduce the proliferation risk posed by neglected, underpaid, and demoralized nuclear weapons scientists and workers, and the potential threat posed by the enormous weapons production capacity of the Russian nuclear weapons complex, new steps are needed to cooperatively reduce Russia's nuclear weapons complex to a size Russia can afford to maintain, appropriate to its post-Cold War missions, and re-employ the scientists and technicians displaced by that downsizing. A substantial investment (running at perhaps $100 million per year for five years)[23] in this effort is needed, focused on four critical areas:

- Fostering private sector job growth in the nuclear cities;
- Employing former nuclear weapons scientists on nonproliferation and arms control policy analysis and technology development;
- Funding Russian, rather than only U.S., scientists to develop technologies for nuclear cleanup, along with other energy and environmental technologies; and
- Shrinking the Russian nuclear weapons complex.

The last of these objectives is particularly critical. Russia will likely remain a nuclear power and require a significant nuclear weapons complex to maintain its arsenal for as long as the United States does. But Russia simply cannot afford the level of upkeep required to ameliorate all of the proliferation risks of its complex if the complex remains its current size. And the U.S. Congress has become increasingly unwilling to provide funding for jobs programs for Russians, without some specific metric by which the nonproliferation or arms reduction payoff can be judged. What is likely to be necessary is to work out a deal under which Russia would commit itself to a specific plan (which it would devise, perhaps in consultation with U.S. experts) for substantially shrinking its weapons complex and the capability of that complex to produce nuclear weapons. The United States, in turn, would commit to provide assistance in that downsizing at dramatically higher levels than the puny $7.5 million Congress provided for the Nuclear Cities Initiative in FY2000—so that in effect, it can be said that "for this much money, we can shut down this much weapons production capability." This would provide a readily quantifiable performance metric similar to the Cooperative Threat Reduction

[23] As noted earlier, DOE has estimated that the cost of providing sustainable employment for 50,000 excess workers in the Russian nuclear weapons complex—possibly an underestimate of the number of people likely to excess—would be in the range of $550 million. See *Report to Congress on the Nuclear Cities Initiative*, op. cit.

program's focus on the number of missiles dismantled, warheads deactivated, and the like.

Private Sector Job Growth

Neither the U.S. government nor the Russian government has the money to keep paying nuclear workers who are no longer needed forever. In the long run, therefore, a combination of private job growth in the nuclear cities, movement of people elsewhere to work, and retirement as existing workers age is the only answer. Given the current economic collapse in Russia, however, fostering private-sector growth and attracting foreign investment anywhere in Russia is a major challenge, and doing it in Russia's nuclear cities will be an extraordinarily difficult task for the near term. These cities face a huge number of obstacles to private sector growth: in addition to the political risks and structural problems that plague private sector activities in Russia in general, the nuclear cities are physically isolated, their closed status makes access difficult (45 days advance permission is typically required for a foreign visit), their populations have virtually no experience with private businesses or a market economy, and they have virtually no business infrastructure (not having needed it in the past). But the cities offer potential opportunities as well, principally a large number of highly skilled scientists and engineers, willing to work at wage rates far below those that prevail in western countries. To overcome these obstacles and seize these opportunities, the traditional approach of most past U.S. efforts related to defense conversion, focused on funding high-tech R&D and providing some business training, will be helpful but will not be enough. The full spectrum of tools that have been used to promote private-sector growth in other areas (in Russia and elsewhere)—business centers, loan guarantees, political risk insurance, start-up capital for new enterprises, tax incentives, and the like—are likely to be necessary.

The interior of one of the buildings being converted to civilian purposes at Avangard, one of Russia's four nuclear weapons assembly and disassembly facilities. The United States should provide substantial funding to help close and convert Russian nuclear weapons complex facilities and reemploy thousands of scientists and technicians, in return for Russian agreement to reduce the complex's ability to mass produce new nuclear weapons and components. Source: Los Alamos

While DOE, which is managing the Nuclear Cities Initiative, is not well suited to employ all of these tools, other U.S. and international agencies are, and it will be essential to draw in their experience and resources. The Regional Investment Initiative established under what was then called the Gore-Chernomyrdin Commission has been designed to target a broad range of types of assistance on particular regions; a similar approach can and should be taken with the nuclear cities (though their economic prospects are much more problematic than those of the regions chosen for the Regional Investment Initiative). It will be critical for the U.S. government to work closely with the private sector—particularly those large firms that have already been involved in the nuclear cities or have explored involvement, such as Microsoft, Intel, and Sun, among others—to find out what forms of support would be needed to leverage larger private sector commitments. Companies such as these should be asked the question: "what would have to happen for you to conclude that it would be in your business interest to put significant quantities of your money into projects in these cities?" Working with other governments—such as the governments that contribute to the International Science and Technology Centers, and the European governments now considering a European Nuclear Cities Initiative—to target similar efforts on these cities is also likely to be key to success.

It appears likely that the areas that have the most promise for a small amount of government investment to lead to substantial private growth and job creation are (a) low-tech small and medium-sized enterprises within the cities, largely providing products and services needed within Russia, and (b) approaches in which Western firms hire nuclear-city experts as knowledge workers (mathematicians, computer programmers, etc.), so that access to secret production lines, transportation of goods, etc. are not major issues. With the shortage of software experts and other engineers in the United States, U.S. firms are increasingly putting together global teams including engineers around the globe, in which experts from the nuclear cities would be prime candidates for participation.[24]

Many of the efforts being pursued in the Nuclear Cities Initiative are focused on these kinds of objectives. The Open Computer Centers being established at Sarov and Snezhinsk, for example, are designed to make it possible for experts from the nuclear cities to work on unclassified civilian software and other engineering projects without ever leaving their home cities. But there is certainly much more that can and should be done, which would be possible with greater financing. To take just one example, even once an enterprise has a viable business concept that meets a real market demand, and a reasonable business plan, it is likely to need start-up capital. The Nuclear Cities Initiative has provided support to make it possible for firms from three of the nuclear cities to compete for the pool of small-business loans available for Russian firms from the European Bank for Reconstruction and Development (EBRD)—but with additional funds, a pool of start-up capital (in the form of equity investments, grants, or loans) could be earmarked specifically for the startup of enterprises within the nuclear cities.

Nonproliferation and Arms Control

Shifting some former nuclear weapons scientists to nonproliferation and arms control activities should also be a fundamental part of the Nuclear Cities Initiative. In a sense, this doubles the "bang for the buck," in that it provides jobs for nuclear scientists while at the same time accomplishing objectives that the United States would want accomplished in any case. While there is no prospect for employing tens of thousands of workers on nonproliferation, for the small cadre of top scientists this can be an important

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[24] See, for example, Zachary G. Pascal, "The Rage for Global Teams," *Technology Review*, July/August 1998.

avenue of employment: in the U.S. case, it appears likely that there are significantly more former weapons scientists that have successfully "converted" to work on nonproliferation and environmental analysis and R&D than there are who are employed by commercial high-tech firms spun off from the labs. If initial U.S. funding helps establish nonproliferation centers of excellence at the Russian weapons labs while providing tangible deliverables to justify the U.S. spending, it can be hoped that, over time, as the Russian government budget improves and the centers establish the importance and value of the work they do, the Russian government itself will ultimately pick up the tab for their continued operation. There are dozens of examples of nonproliferation and arms control issues crying out for the application of additional expertise of the kind nuclear weapons scientists could bring to bear—from developing databases of key technologies on which to base nuclear export control decisions, to developing means to verify deep reductions in nuclear warhead and fissile material stockpiles. Recently, a collaboration between U.S. non-government organizations and foundations and the U.S. government has provided start-up funding for new nonproliferation and arms control analysis centers at Sarov (formerly Arzamas-16), Snezhinsk (formerly Chelyabinsk-70), the Kurchatov Institute in Moscow, and the Institute of Physics and Power Engineering at Obninsk, but there is far more that could be done.[25]

Nuclear Remediation, Energy, and Environmental Technologies

The United States certainly does not have the funds to pay for cleanup of the Russian nuclear complex, or for broad-scale deployment of new energy and environmental technologies in Russia. But these are all areas where the United States government funds hundreds of millions of dollars of R&D annually—a small portion of which might be done by experts from Russia's nuclear cities. This would be a win-win-win approach: the United States would get the work done for less (given the low wage rates in Russia), Russian nuclear experts would get challenging and interesting work making use of their skills, and both sides would be able to make use of the resulting technologies. Development of nuclear cleanup technology, in particular, is a "natural" for conversion in the nuclear cities: both the United States and Russia face massive nuclear cleanup problems in their nuclear complexes, and Russian experts can bring a range of fresh ideas to the U.S. cleanup R&D program at low cost—as well as heavily contaminated sites where the technologies they develop could be tested. More broadly, it would make sense for the Secretary of Energy to pull together all the leaders of DOE programs that sponsor substantial R&D programs and ask them to prepare lists of projects in their areas that could be accomplished cost-effectively by contracting efforts to experts from the Russian nuclear cities.[26] By this means, tens of millions of dollars in near-term funding for real jobs in the Russian nuclear cities could be arranged in a manner that

[25] These centers were established at the initiative of RANSAC, particularly by Kenneth N. Luongo and Frank von Hippel. For further discussion of nonproliferation and arms control programs that could be pursued, see, for example, Bunn et. al., "Retooling Russia's Nuclear Cities," op. cit.

[26] The author is grateful to Siegfried Hecker for suggesting this concept; Hecker and others at the Los Alamos, Livermore, Sandia, and Pacific Northwest laboratories have elaborated this idea in a "Contract Research Initiative" now being considered by the Department of Energy.

would contribute to, rather than detracting from, the other priorities of the U.S. government.

Shrinking the Russian nuclear weapons complex

Today, Russia's still maintains a massive nuclear weapons infrastructure, capable—if Russia had the funds—of producing thousands of nuclear weapons components and nuclear weapons a year. The United States, by contrast, has downsized its complex to the point that it no longer has the capability to produce more than a few hundred nuclear weapons or components annually (if that). With the end of the Cold War, Russia has no need for a nuclear weapons complex of this scale, and maintaining it is a drag on Russia's scarce economic resources. Thus, it is in both the U.S. and Russian interest to substantially reduce the capacity of the remaining weapons production infrastructure in Russia. Russia has already announced that it will close two of its four nuclear weapons assembly and disassembly facilities in the next few years (the two smallest, the Avangard plant at Sarov, and the plant at the closed city of Penza-19); the NCI should work with Russia not only to provide alternative employment for the workers at these facilities, but to ensure that the weapons assembly facilities themselves are destroyed or demonstrably converted to other purposes. More broadly, the United States should encourage Russia to develop a coherent plan for the transition to a greatly downsized nuclear complex, working informally on a lab-to-lab basis to provide information on the U.S. experience of planning the downsizing (which Russia has requested), and perhaps even working together to sketch out plans for a slimmed-down, sustainable complex for the future—a "MINATOM 2010," as some have called it.

While the future of Russia's closed nuclear cities is critically important, it must also be remembered that there are many nuclear facilities with potentially vulnerable nuclear material which are *not* in the closed cities, whose future must also be addressed. Russia's civilian nuclear complex, like its nuclear weapons complex, is larger than is likely to be sustainable over the long haul—yet the managers of each facility would like to keep their facility open. Little high-level planning has gone into thinking about what facilities should stay on their present course, what facilities should be redirected to other missions, and what facilities should be closed. Wherever there are facilities with weapons-usable material or weapons-related information, there are U.S. interests at stake, and the United States should work with Russia to initiate a sustainable transition to a smaller complex, with appropriate alternative employment for the excess nuclear experts.

Dealing with the excess personnel and infrastructure of the Russian nuclear complex is critical to U.S. objectives in security cooperation with Russia, and these issues should be factored into all U.S.-Russian programs. The MPC&A program, for example, is spending tens of millions of dollars a year in Russia; efforts should be made to ensure that this spending also contributes to employing excess personnel from the nuclear facilities and other potentially vulnerable nuclear facilities. Similarly, the plutonium disposition program will require large-scale plutonium processing facilities: serious consideration should be given to converting the existing plutonium processing facilities designed to fabricate components for nuclear weapons to convert those components to oxide and fabricate the oxide into fuel.

Monitoring Stockpiles and Reductions

The ultimate goal of U.S.-Russian transparency efforts should be an integrated, comprehensive regime that would provide confidence that each side was reducing its total nuclear warhead and fissile material stockpiles to low levels, and that these stockpiles were safe and secure.[27] With U.S.-Russian relations as they are in the wake of the bombing of Yugoslavia, however, that goal is a long way off; U.S.-Russian political tensions and renewed concerns over protecting nuclear secrets on both sides are likely to make near-term progress on nuclear transparency extraordinarily difficult. Paradoxically, it appears that the best hopes would be for initiatives that were either very large (so that they might have some chance of addressing Russian security concerns and shifting the political environment in favor of cooperation) or very small (so that they could be pursued informally without drawing undue political attention in either country). A few of the steps that should be pursued are listed below.[28]

Nuclear Material Stockpile Data Exchanges

Achieving a better understanding of the actual quantities, forms, and locations of fissile material in each country is fundamental to cooperative efforts to secure, monitor, and reduce these dangerous stockpiles. The United States has openly published data on its plutonium stockpile and plutonium production, and is preparing to publish similar data concerning its HEU stockpile. As noted in Section III, preliminary U.S.-Russian discussions suggest that it may be possible to work out an informal arrangement under which Russia would provide data on its plutonium stockpile comparable to the data the United States has already published on its own stockpile, and the United States would provide the funding Russian experts need to compile the data. This informal approach, if successful, could then be applied for HEU inventories, once the United States releases that data. This would provide a rapid means to accomplish a substantial part of the stockpile data exchange agreed to by Presidents Clinton and Yeltsin in 1994 on a contracting basis, without requiring high-level formal negotiations that would draw widespread political attention. The cost would likely be only a few million dollars.

International Monitoring of Excess Fissile Material

A key issue in the U.S.-Russian-IAEA “Trilateral Initiative” described in Section III is who will pay the costs of monitoring materials in Russia. (To date, the United States has been paying both its own costs and the IAEA’s costs of monitoring the small amount of excess material that is under IAEA verification so far in the United States.) Russia is very unlikely to be able or willing to provide the funding to pay these costs, a

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[27] See, for example, discussion in *Management and Disposition of Excess Weapons Plutonium*, op. cit.

[28] For an excellent recent discussion of transparency measures, with some similar suggestions, see Oleg Bukharin and Kenneth Luongo, *U.S.-Russian Warhead Dismantlement Transparency: The Status, Problems, and Proposals*, Princeton, NJ: Center for Energy and Environmental Studies, Princeton University, Report 314, April 1999 (available at http://www.princeton.edu/~ransac).

problem that could stop the initiative in its tracks. The IAEA has proposed the creation of a special disarmament fund to pay for such costs, which might ultimately receive funds from mandatory assessments; the United States could kick-start the effort with an initial voluntary contribution to the fund, and could agree to pay for Russia's costs to host the IAEA inspections (a cost category very unlikely to be covered by an international fund). U.S. agreement to pay these costs could enable a significant nonproliferation and disarmament initiative to go forward, at a very modest cost (probably a few million dollars per year initially, and less after the arrangement is established).

In a lab-to-lab effort, U.S. and Russian weapons scientists are jointly developing transparency technologies and procedures to confirm the dismantlement of nuclear weapons without revealing classified information. The United States should offer a reciprocal initiative under which thousands of U.S. warheads would be placed in secure storage open to Russian monitoring, and committed to eventual dismantlement, if Russia agrees to do the same with thousands of its own warheads. As part of the package, the United States should also offer to provide financial help for warhead dismantlement in Russia, with reciprocal transparency to confirm the dismantlement. Source: DOE

A Major Transparent Warhead Reductions Offer, With Assistance for Transparent Warhead Dismantlement

With the current state of U.S.-Russian relations, there is very little chance that the START II treaty will be ratified and formal negotiations completed on a START III treaty incorporating the unprecedented transparency measures for the dismantlement of warheads envisioned in the Helsinki statement of 1997 before President Clinton leaves office. Even in the unlikely event that a framework agreement on START III and national missile defenses can be achieved by the end of President Clinton's term, dismantlement transparency measures are likely to be postponed or included only as initial small-scale demonstrations. Informal reciprocal-unilateral initiatives—such as those launched by President Bush and Soviet President Gorbachev in 1991, which resulted in the pull-back and dismantlement of many thousands of nuclear weapons, without requiring formal negotiations—represent the only near-term hope for a breakthrough in transparent nuclear arms reductions. To gain acceptance on both sides in the current political environment, such an initiative would have to address concerns each side has about the other's nuclear stockpile. For example, President Clinton could offer to place a large fraction of the U.S. strategic reserve and tactical nuclear warheads (stockpiles unregulated by arms control to date, and which will represent the vast majority of the total U.S. warhead stockpile under START II) in secure storage open to Russian monitoring, and commit them to verifiable dismantlement (with specific procedures to be worked out later), if Russia would do the same with its comparable warhead stockpiles. This could address Russian concerns about the U.S. maintenance of a large stockpile of reserve strategic warheads that could be rapidly returned to missiles, and U.S. concerns about the huge Russian tactical warhead stockpile. Within a few months, the majority of all the warheads in both sides' nuclear arsenals could be under reciprocal monitoring, and committed to dismantlement.[29] Indeed, technology exists that would make it possible to permanently and verifiably disable these warheads, pending their eventual dismantlement, rather than only subjecting them to monitoring.[30] As part of this package, the United States could offer to provide financial assistance for warhead dismantlement (e.g., $90 million per year for a dismantlement rate of 3,000 per year, or roughly $30,000 per warhead) in return for Russian agreement to a transparency package that would also be implemented reciprocally at the Pantex dismantlement facility in the United States. The transparency measures would have to be designed jointly by U.S. and Russian experts, to give both sides confidence that while the measures could help confirm that dismantlement was taking place, they would do so without revealing sensitive information or unduly interfering with maintenance of each side's nuclear stockpile. As noted earlier, preliminary U.S.-Russian lab-to-lab work in designing such measures is already under way; U.S. experts have already produced reports on the impact of a variety of dismantlement transparency approaches at U.S. facilities, and it would make sense for the United States to help finance a Russian effort to do the same with respect to Russian facilities.[31]

Ending Further Production

As discussed in Section III, while the program to convert Russia's remaining plutonium production reactors has faced mounting safety, nonproliferation, cost, technical, and schedule issues, there may now be an opportunity to pursue a superior approach—shutting these reactors down and providing other sources of heat and power to replace them. If this can in fact be accomplished at comparable cost and in a comparable time, such a shut-down-and-replacement strategy would better serve both the nonproliferation objectives and the safety objectives held by both sides. Indeed, this was the approach originally favored by both parties, and called for in the 1994 agreement; it was only doubts about its cost that drove the parties in the direction of conversion.

The United States should provide the funding necessary for a new, in-depth examination of least-cost possibilities for replacing the heat and power provided by these nuclear reactors. Both cities have partially completed fossil fuel plants, and as the Ministry of Atomic Energy suggests, completing some coal and oil-fired plants and expanding others may turn out to be the cheapest approach. Other possibilities should also be examined, however. Seversk is in a region with substantial supplies of natural gas, and if a pipeline can provide gas to the town at reasonable cost, a combined-cycle gas

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[29] For a description of this concept, see Matthew Bunn, "Act Now, Mr. President," *Bulletin of the Atomic Scientists*, March/April 1998. For a similar proposal applying to active-duty strategic forces, see Admiral Stansfield Turner, *Caging the Nuclear Genie: An American Challenge for Global Security*, Boulder, CO: Westview Press, 1997. See also Committee on Nuclear Policy, *Jump-START: Retaking the Initiative to Reduce Post-Cold War Nuclear Dangers*, Washington DC: Henry L. Stimson Center, February 1999 (available at http://www.stimson.org/policy/jumpstart.htm).

[30] See Matthew Bunn, "'Pit-Stuffing': How to Disable Thousands of Warheads and Easily Verify Their Dismantlement," *F.A.S. Public Interest Report*, March/April 1998.

[31] See discussion in Luongo and Bukharin, "U.S.-Russian Warhead Dismantlement Transparency," op. cit.

plant with cogeneration to provide the needed heat might very well be the least-cost alternative. Zheleznogorsk is in a region with a significant excess of hydropower capacity—some of which could potentially be used to produce heat as well, either through electrical heating of buildings or through running the existing centralized district steam heating system with electricity. In both cities, there are enormous opportunities to reduce energy needs through efficiency improvements at low cost, thereby reducing the amount of energy required and the cost of providing it. In short, while an in-depth study of the options is urgently needed, there are good reasons for optimism that approaches can be found for replacing these reactors for a cost comparable to that of the conversion project.

Three other key issues relating to fissile material production remain to be addressed:

- The United States should work with Russia to develop and implement reciprocal transparency measures at U.S. and Russian enrichment facilities to confirm that neither country is producing HEU. These measures could provide a test-bed for approaches to verifying a fissile cutoff treaty, at a cost likely to be in the range of $10 million per year, or less.
- The United States should offer to finance the costs of verification of an international fissile material production cutoff at Russian reprocessing plants. Older reprocessing plants never designed for safeguards—as exist in both the United States and Russia—are likely to be the biggest verification challenge for a cutoff, and are likely to cost more than Russia will be willing to pay in the near term, but putting such verification in place would be a sensible security investment, contributing to a global cutoff while improving material control and accounting at Russian reprocessing plants. It would also make sense to begin immediately to carry out small-scale cooperative experiments at U.S. and Russian reprocessing plants to demonstrate technologies and procedures for such verification.
- If, as seems likely to be the case, Russia resists the proposal for a reprocessing moratorium in the absence of other employment for the workers at its commercial reprocessing plant, the United States should offer a cooperative program that would provide alternative employment for these workers. This effort, while linked to a reprocessing moratorium, should be an integral part of the broader program to re-employ excess nuclear weapons scientists and technicians described above.

Reducing Excess Stockpiles

Finally, the vast stockpiles of HEU and plutonium built up over decades of Cold War must be rapidly, safely, and securely reduced, to levels sufficient to support whatever agreed warhead stockpiles remain, but which can no longer support a rapid return to Cold War levels of armament. The immediate priorities are to provide safe and secure storage for these materials, and place them under bilateral or international monitoring to confirm that they will never be returned to weapons—both discussed above. But even once those goals are achieved, far more needs to be done to physically transform these materials into unclassified forms (allowing more intensive monitoring), and ultimately into forms that can no longer be readily used in nuclear weapons, as quickly as practicable.

Highly Enriched Uranium

For both HEU and plutonium, the first needed steps are to take the actions necessary to complete and implement the existing agreements. In the case of the HEU deal, while the current approach of slapping one temporary band-aid after another on a basically flawed implementation strategy may suffice to keep the deal moving for the time being, there are likely to be continuing crises, delays, and requirements for U.S. government intervention as long as (a) USEC remains the sole executive agent, with no competition to create incentives for the material to be purchased at fair market prices; and (b) trade restraints continue to tightly restrict the amounts of Russian uranium and enrichment work that can be brought into the United States and other major Western markets. The time has come for a fundamentally new approach, involving new executive agents and loosened trade restraints. Whatever approach is taken, keeping this deal moving deserves extremely high priority: given the amount of material and money involved, and the incentives the deal creates for dismantlement of weapons and destruction of fissile material, this deal is probably the single most crucial U.S.-Russian fissile material control initiative.

But in addition to keeping the existing deal on an even keel, it is crucial to begin pursuing new uranium agreements—both faster blend-down of HEU and new purchases going beyond the original deal. Negotiations toward the following objectives should be pursued immediately.

Finance Rapid Excess HEU Blend-Down. There is an enormous opportunity to drastically accelerate the rate at which HEU is blended to LEU that can no longer be used in weapons, which has not yet been thoroughly explored. The current 30-ton-per-year pace of blending for the HEU purchase agreement was determined by what the commercial market could bear, not by what would best serve U.S. or Russian security interests. From a security perspective, it would be desirable to blend all Russian and U.S. excess HEU to non-weapons-usable form—perhaps to an intermediate enrichment level of 19%—immediately, resolving the key nonproliferation and disarmament issues this material poses, even while it continues to be released onto the commercial market at a much lower pace. It would be essential to take care that the blending approach did not interfere with achieving the isotopic mix in the LEU ultimately desired for a commercial product.[32] U.S. experts visiting Russian facilities have concluded that nearly all the facilities needed

[32] Currently, the HEU is not being blended with depleted uranium or natural uranium, but rather with slightly enriched uranium (1.5 percent U-235), in order to reduce the U-234 concentrations in the final LEU product to meet the standards used by Western reactor fuel manufacturers. To meet this objective after an initial blending step as described in the text, either the initial blending would also have to be done with 1.5 percent enriched material, or the initial blending might be done with natural or depleted uranium and later final blending done with material of somewhat higher enrichment than 1.5 percent. Another complicating factor is that the material also requires chemical purification to meet Western standards, and capacity for this process appears to be among the principal limiting factors on the blending rate, suggesting that this capacity would either have to be increased, or purification would have to be done after the initial blend-down (which would require that several times as much material be purified). The author is grateful to Thomas L. Neff (who published the first proposal for the HEU deal in 1991), Oleg Bukharin, and Richard L. Garwin for discussions of what would needed to accomplish a rapid blend-down of HEU to non-weapons-usable levels.

Real-time monitoring equipment is installed at this point where a pipe carrying 90% enriched gas meets a pipe carrying 1.5% enriched uranium gas to produce 4.4% enriched uranium for the U.S.-Russian HEU Purchase agreement. (The blend point is labeled "Dave's point" after one of the U.S. designers of the equipment, shown in the photo.) The United States should offer to pay Russia to drastically accelerate this blend-down, with the goal of eliminating the proliferation risk posed by excess HEU within a few years. Source: DOE

to blend HEU at twice the current rate are already in place; the remaining required capabilities could be installed for a capital investment of only about $1 million. Doubling the blending pace would mean the destruction of enough additional HEU for thousands of nuclear bombs every year. No one has yet studied in detail what additional blending capacity might be available for investments of $10 million, or $20 million, or $50 million. In principle, the goal should be to work with Russia to blend down both the 500 tons declared to date and any additional HEU Russia can be convinced to declare excess, of the vast military reserve of HEU that remains, within a very few years.

Gaining Russian agreement to such a rapid blend-down plan—which would involve blending far more material each year than the market could be expected to absorb—would require offering substantial financial incentives. The United States could offer to pay the costs of this early blending as an investment in security, employing hundreds or thousands of additional MINATOM nuclear workers, and making later preparation of the material for sale on the open market essentially free for MINATOM. The total price, including paying MINATOM's costs and other financial incentives, has not been examined in detail, but might be in the range of $1 billion—a remarkable price to pay for permanently resolving the security hazards posed by excess HEU in Russia. Russia might well be concerned that once the material was blended to a non-weapons-usable form, so that it no longer posed a security hazard, U.S. officials would cease to put very much effort into fixing the continuing problems with its release onto the commercial market, which is where the biggest money for this material lies. That concern might be addressed, for example, by having a substantial portion of the U.S. payment for the early blend-down be in the form of a pre-payment against future deliveries—so that the U.S. government would have a substantial financial incentive to keep the material flowing onto the commercial market so as to get its money back.

DOE has undertaken some preliminary discussions with Russia concerning the possibility of additional HEU blending; Russia's principal concern has been over whether it would be possible to sell more material on the market than is now being blended. To date, the U.S. government has not offered to pay the cost of rapid blending from U.S. government funds, obviating the need to find an immediate market for the additional blended material.[33] DOE should immediately undertake a study, in cooperation with Russia, of what would be required, how much it would cost, and how long it would take. Once the HEU has been converted to forms that could potentially be sold on the market (and thus have commercial value without requiring further work), there may also be opportunities for using the blended-down material as collateral against which Russia could borrow, which should also be considered in such a study.[34] The U.S. government should then move rapidly to negotiate and implement an agreement with Russia to blend all the excess HEU in both the United States and Russia to non-weapons-usable form as quickly as practicable.

Buy Additional Quantities of Excess HEU. Russia clearly has far more HEU that is excess to its needs for its military stockpile than the 500 tons it has formally declared excess to date. (Indeed, some Russian facilities have raised with U.S. counterparts the possibility of selling additional HEU above and beyond the 500 tons covered by the HEU deal.) The United States should offer to buy additional stockpiles of excess HEU, up front rather than at the end of the current deal, with government funds rather than money from commercial firms. These additional purchases should be up-front because offering to buy more material at the end of the current deal, in 2013, has little meaning to Russian ministries and facilities struggling to pay the bills through 2002; it should be done with government money because (unless there are drastic changes in the restrictive trade policies of the major nuclear markets) the commercial market is already absorbing all the excess Russian HEU it can bear. The material could be held off the market as a strategic uranium stockpile (rather than flooding the market immediately with this additional HEU).

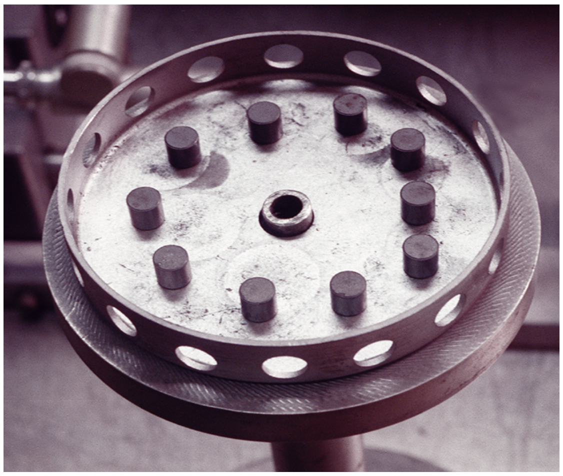
As a first step, the United States should offer to buy an additional 50 tons of HEU (at a cost of roughly $1 billion at the prices currently pertaining in the deal), while stipulating in the contract that a substantial portion of the proceeds be placed in a fund to pay for nuclear security measures (see "Generating New Revenue for Nuclear Security," p. 86). If this first step succeeded, it would make sense to continue with additional purchases, ultimately buying all the excess HEU Russia was willing to make available (with transparency to confirm that additional HEU was not being produced, as discussed above). In addition, if Russia was willing, it is worth considering purchasing some of this material as HEU, to be shipped to the United States for blending (after any classified information had been removed), rather than blending it all in Russia—as former Minister of Atomic Energy Victor Mikhailov once proposed. This would get that portion of the HEU out of Russia more rapidly, and reduce the cost to Russia of the blending—but would also raise issues of security during the intercontinental transport, and would mean

[33] Information from interviews.

[34] This concept was suggested to the author by David Pentz, chairman of Pangea, a firm which is seeking to build an international nuclear waste repository in Australia. Commercial banks are typically unwilling to accept uranium stocks as collateral for loans unless contracts are in place for their sale, since the banks do not want to be stuck having to market the uranium themselves in the event of foreclosure; but Russia now has such a sales contract for the natural uranium resulting from the HEU deal for years to come. Moreover, such blended uranium stockpiles might provide acceptable collateral for governments or institutions such as the IMF to make loans (or pre-payments against future deliveries). The author is grateful to Thomas L. Neff for discussions of these points.

that American rather than Russian workers would get the blending jobs. Russia may legitimately no longer be interested in such an approach.

If Russia were willing to sell an additional several hundred tons of HEU (while still maintaining a large enough reserve to support its reduced nuclear warhead stockpile), the cost could mount to as much as $10 billion. The rapid blend-down and additional purchase concepts could be combined, so that the U.S. government actually purchased only a fraction of the material blended to LEU, leaving the rest to continue being metered onto the commercial market at roughly current rates, and thereby substantially reducing the total purchase cost to the U.S. government. As an integral part of any such expanded purchases, monitoring should be put in place (in both the United States and Russia) to confirm that no new HEU is being produced.



Uranium-plutonium mixed oxide (MOX) fuel pellets for nuclear reactors, made from excess weapons plutonium. The United States should offer to finance the costs of disposition of Russia's excess plutonium, as the $1-$3 billion cost of the project is small by comparison to the security risk posed by this dangerous stockpile.
Source: Los Alamos

Plutonium

In the case of plutonium, the essential first steps (beyond ensuring that it is secure and accounted for, and placed under international monitoring) are to put in place the financing and the additional reactor capacity needed to implement the nearly completed U.S.-Russian draft agreement, and to carry out the engineering and institutional steps needed to begin.[35] As with HEU, however, there is also a need to move rapidly toward disposition of additional material, and to consider fallback plans if current approaches do not succeed.

Finance Russian Plutonium Disposition. Following on the lead Senator Domenici provided with the $200 million down-payment for Russian plutonium disposition in the fiscal 1999 budget, the United States should offer to cover the costs of disposition of Russian plutonium, allowing this effort to finally move forward. The $1-$3 billion cost is small by comparison to the magnitude of the security stakes in eliminating Russia's huge excess plutonium stockpile. To date, talks with other countries on sharing this cost have made little progress—and the additional complication of involving more countries in the process may be more than the contributions that can reasonably be expected are worth. This funding would cover the construction or modification and operation of the facilities needed to convert Russian plutonium weapons components to oxide, fabricate that oxide into fuel, and irradiate that fuel in reactors.

[35] For a comprehensive set of next steps for excess plutonium, agreed by a panel of U.S. and Russian experts, see *Final Report of the U.S.-Russian Independent Scientific Commission on Disposition of Excess Weapons Plutonium,* op. cit.

Nail Down Commitments for Additional Reactor Capacity for Disposition. As described earlier, the United States and Russia are negotiating a plutonium disposition agreement that would ultimately require disposition of at least 4 tons of Russian plutonium per year, yet with the approach currently envisioned, existing modern Russian reactors could not irradiate more than 2 tons of plutonium per year, if that much. The United States should put redoubled priority on putting together a specific plan, and negotiating agreements with all the relevant parties that would allow it to be implemented, within the next year. This would include agreements on whether Russian, Ukrainian, Canadian, European, and/or Japanese reactors would be used, and in what combination. If that is not accomplished, Congressional unwillingness to fund construction of U.S. plutonium disposition facilities without a Russian plutonium disposition program proceeding in parallel could cause the entire plutonium disposition effort to come unraveled—and it would then be quite difficult, after years of delay, to convince a future Congress that it was suddenly urgent to provide the funds needed to begin again.

Considering Additional Approaches. There are several additional approaches to the plutonium problem that deserve serious consideration:

- **Pursuing alternative financing arrangements.** Convincing Congress to provide full funding for disposition of Russian plutonium—or convincing other states to make much larger contributions than they have to date, as the U.S. government currently hopes to do—would require a substantial investment of presidential leadership. If the White House fails to provide such leadership, alternative approaches to providing this funding that might involve less on-budget government expenditure will have to be pursued. One possibility would be to finance plutonium disposition with additional HEU sales. In one concept, for example, a joint venture between MINATOM and various Western fuel cycle and construction firms would be established for the purpose of building and operating the needed plutonium disposition facilities in Russia. MINATOM would provide this joint venture 100 tons of HEU (above and beyond the 500 tons covered by the HEU purchase agreement), and Western countries would agree to modify their uranium and enrichment trade restraints enough to allow this additional increment of material could enter their restricted markets. The joint venture would then have an asset worth roughly $2 billion—enough to pay for blending and delivery of the uranium, as well as construction and operation of the plutonium disposition facilities. The MOX produced would be marketed at prices well below the prices paid by utilities for LEU fuel, to give the utilities an incentive to take it—prices which would be sufficient to cover operations costs for fuel fabrication, but not to pay back any of the initial cost of the plant. By this means, it would be possible to get rid of both Russia's excess plutonium and an additional 100 tons of HEU, without the need for additional government appropriations.[36] Another approach would be to use revenue generated from commercial storage of spent fuel in

[36] See Matthew Bunn, "Getting the Plutonium Disposition Job Done: The Concept of Joint-Venture Disposition Enterprise Financed By Additional Sales of Highly Enriched Uranium," in V. Kousminov and M. Martellini, ed., *Science for Peace Series Vol. 1: International Conference on Military Conversion and Science: Utilization-Disposal of the Excess Fissile Weapons Materials: Scientific, Technological, and Socio-Economic Aspects,* Como, Italy: UNESCO Venice Office, 1996.

Russia for disposition of excess plutonium (see "Generating New Revenue for Nuclear Security," p. 86).[37]

- **Buying Russian Plutonium.** Although plutonium has no value on today's commercial nuclear fuel market, for national security reasons it would make sense to explore with Russia the possibility of buying Russia's excess plutonium. Since plutonium has the same energy value as HEU, but is more costly to actually use as fuel, there would be no reasonable argument for a per-ton price any higher than the United States is paying for HEU, resulting in a price of no more than $1 billion for the 50 tons declared excess to date. The most plausible approach would probably be to leave the material in Russia after it was purchased, in a facility owned and operated by the United States; shipping it to the United States would raise extraordinarily difficult political and legal issues in both Russia and the United States. Wherever the material was located, the United States would then have to pay the cost of storage and disposition as well, which could add $1-$3 billion to the cost, as discussed above. In some public statements, Russian officials have indicated that Russia would never sell its plutonium; in some private discussions, however, some senior Russian officials at MINATOM and elsewhere have been willing to at least consider the possibility. Because the United States has never made a serious effort to explore the issue with Russia, no one really knows what Russia's reaction to a real offer would be—and the answer might depend substantially on how the offer was made, and details of how the transfer of classified information would be avoided, and where the plutonium would eventually end up. A somewhat similar proposal is to offer a substantial financial incentive, perhaps $10,000 per kilogram ($500 million for 50 tons) for Russia to deposit its plutonium in a facility in Russia with international (rather than purely national) guards and monitors, and, for reciprocity, have the United States deposit its excess plutonium in a facility in the United States under similar arrangements.[38] A more radical idea is to set up a single facility in some third country, where all the U.S. and Russian excess material—and perhaps excess warheads as well—would be stored.[39] Obvious obstacles to that concept include obtaining the agreement of Russia, the United States, and the third country.
- **Using MOX Plants That Already Exist.** In Europe, large MOX plants already exist that are fabricating civilian plutonium into fuel, and reactors are already licensed and operating with MOX fuel. If the complex political obstacles could be overcome, therefore, by far the fastest approach to disposition of excess weapons plutonium would be to ship both U.S. and Russian excess plutonium to Europe as rapidly as it could be converted to unclassified forms, and have these existing facilities (which

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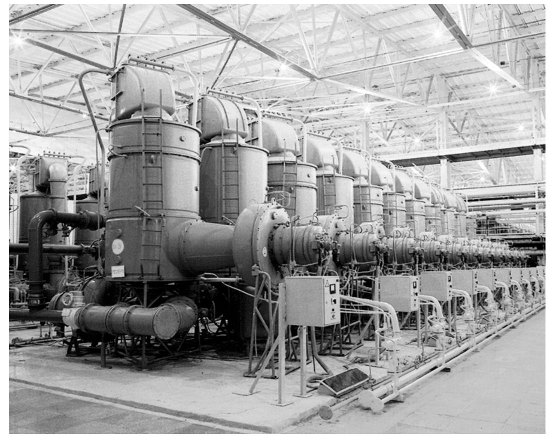
[37] For a proposal along these lines, see Matthew Bunn, Neil J. Numark, and Tatsujiro Suzuki, "A Japanese-Russian Agreement to Establish a Nuclear Facility for MOX Fabrication and Spent Fuel Storage in the Russian Far East," BCSIA Discussion Paper 98-25, Cambridge, MA: Kennedy School of Government, Harvard University, November 1998.

[38] For a description of this "plutonium bank" idea, see Ashton B. Carter and Owen Coté, "Disposition of Fissile Materials," in Graham Allison, Ashton B. Carter, Steven E. Miller, and Philip Zelikow, eds., *Cooperative Denuclearization: From Pledges to Deeds*, CSIA Studies in International Security No. 2, Cambridge, MA: MIT Press, 1993.

[39] See Brian Chow, Richard H. Speier, and G.S. Jones, *A Concept for Strategic Material Accelerated Removal Talks*, DRU-1338-DOE, Washington DC: RAND Corporation, 1996.

are now fabricating some 10 tons of plutonium into MOX every year) fabricate MOX from weapons plutonium instead of fabricating it from the civilian plutonium they are scheduled to use. This could be done as a "plutonium swap," in which Russia and the United States would effectively give the Europeans title to the excess weapons plutonium, in return for receiving title to the civilian plutonium that would be displaced by fabricating the excess weapons plutonium. Thus, Russia and the United States (as well as the Europeans) would each own just as much plutonium as before—but the plutonium owned by the United States and Russia would be reactor-grade, and stored in highly secure, well-paid for facilities in Europe under international safeguards, thereby virtually eliminating both the risk of theft and the risk that it would be returned to the U.S. and Russian arsenals, more rapidly than other schemes could match. When this concept was publicly broached by Senator Domenici, however, the Europeans strongly opposed it (largely on grounds that it might disrupt their ongoing plutonium recycling plans—though there is no technical reason why it need do so), and it has never been pursued further.[40] But if a significant level of U.S. leadership and some money were put behind such a scheme, the outcome might be very different.



Diffusion machinery for uranium enrichment in the closed city of Novoural'sk (formerly Sverdlovsk-44). The United States should offer to buy substantial additional quantities of Russian HEU, with a part of the proceeds to go to fund nuclear security activities such as ensuring that nuclear guards are paid—with reciprocal monitoring at U.S. and Russian facilities to confirm that no new HEU is being produced. Source: DOE

- **Immobilization of Russian Plutonium.** Russia has refused to consider throwing its plutonium away as waste, and therefore, except for some modest joint experimentation on related technologies, there has been little serious pursuit of the immobilization option for Russian plutonium. But even more than in the U.S. case, there are significant risks that the MOX track for Russian excess plutonium could fail, making it critical to have a backup plan in place. If the difficulties in finding enough reactors to burn the Russian plutonium continue to mount, and the costs that would have to be borne by the United States or the international community continue to increase, immobilization may provide a cheaper and simpler alternative. Given official Russian opposition to any plan that does not provide them some benefit for the "value" of their plutonium, perhaps the only possibility for immobilization to move forward on a substantial scale would be for the United States to simply buy the

[40] For a description of the basic approach, see Thomas L. Neff, presentation to the 5th International Policy Forum: Management and Disposition of Nuclear Weapons Materials, March 24, 1998; for a press report of the results of Domenici's discussions with the Europeans on this subject, see Dave Airoso, "Finding Europeans Disinterested, Domenici Gives Up on 'Global Burn'," *Nuclear Fuel*, July 27, 1998.

plutonium from Russia (thereby gaining the right to decide what should be done with it) and then pay to have it immobilized in Russia (which would probably be simpler in a variety of respects than shipping it to the United States to become part of the U.S. plutonium disposition program). Given that Russia has an operational high-level waste immobilization facility, and large plutonium weapons component fabrication facilities that might conceivably be modified for plutonium immobilization, it is at least possible that the combined costs of purchasing Russia's plutonium and paying for it to be immobilized would be the same or less than the cost of pursuing the MOX approach as currently planned, and that possibility should be actively examined.[41]

Deeper Reductions in Fissile Material Stockpiles

Finally, reductions in these stockpiles need to go far deeper than either the United States or Russia presently plan, if the goals of substantially reducing theft risks and ensuring the irreversibility of deep reductions in nuclear arms are to be achieved. The quantities of fissile material the United States and Russia have declared excess to date leave enough material in reserve to support a rapid return to Cold War levels of nuclear armament (see "Enormous Excess Stockpiles—And Still Larger Remaining Military Stocks," p. 54). If genuine irreversibility is to be achieved, new agreements will have to address these "extra," reserve stockpiles. The United States and Russia should work toward putting in place agreements to reduce their *total* stockpiles of nuclear warheads—not just those deployed on active strategic systems—to low levels, and to reduce their fissile material stockpiles to the levels necessary to support the agreed remaining number of warheads. As noted above, verifying the total stockpiles of warheads and fissile materials will be a difficult task, requiring major breakthroughs in transparency and openness. This already tall order will be further complicated by the fact that Russia has larger stockpiles of warheads, plutonium, and HEU than the United States, requiring a shift from the equal reductions in plutonium stockpiles envisioned in the first plutonium disposition agreement to the START concept of "reduction to equal levels, not equal reductions."

[41] For a provocative discussion, see Adam Bernstein and Allison MacFarlane, "Canning Plutonium: Faster and Cheaper," *Bulletin of the Atomic Scientists,* May/June 1999.

V. CONCLUSION: A TIME FOR LEADERSHIP

Unfortunately, there is no single “silver bullet” that will address the myriad risks to international security posed by the gigantic nuclear stockpiles and complex of the former Soviet Union. A broad “next wave” of new measures to reduce these risks is needed, representing roughly a doubling or tripling of current funding for programs devoted to reducing these security threats. Such an expanded effort can only succeed in close cooperation with the states of the former Soviet Union, who will have to play a central role in its design from the very outset. While important progress is already being made in nuclear security cooperation with these states, at the current pace there can be no confidence that a proliferation catastrophe will be averted, or the foundation laid for transparent and irreversible nuclear arms reductions.

To reinvigorate these efforts with new initiatives, to make them work as a package, to coordinate, prioritize, and integrate them into a strategic plan, and to negotiate them with Russia and the other former Soviet states, will require a dramatic increase in sustained leadership from the highest levels of the U.S. government. Too often in recent years, President Clinton has said a few words about the high priority of these issues, and then has failed to follow through with the sustained commitments of money, personnel, and political attention needed to get the job done. President Clinton, Vice President Gore, and their White House staff have allowed myriad other events to distract attention from the fundamentally important task of ensuring that the essential ingredients of nuclear weapons do not fall into the wrong hands.

There is still time to correct this situation—and if President Clinton fails to do so, the next President must act. In addition to a sea change in sustained presidential leadership on these issues, two fundamental steps are necessary: the appointment of a senior official with direct access to the President, with full-time responsibility to carry out and coordinate these efforts, and the development of a strategic plan setting priorities, targets, and timetables, and identifying the key synergies among the many efforts being pursued.

A Senior Coordinator

The current organizational structure of the government, with programs scattered through many departments and no senior leadership engaged on a daily basis at the White House, is simply not suited to the task of managing this broad range of crucial nonproliferation and arms reduction efforts. Today, no one is in charge: there is literally no one in the White House or anywhere else in the government with *full-time* responsibility for coordinating the many efforts described in this report—as opposed to having this responsibility as one of dozens of other responsibilities. Each project is being pursued in its own little "stovepipe," with only ad hoc (and frequently ineffective) efforts at coordination with the many other related programs underway. Effective and coordinated action to reduce these risks will require designating a senior, full-time point person for the effort, with appropriate staff and resources, and with both authority deriving directly from and direct access to the President—on the model of former Secretary of Defense William Perry's return to government to reshape the U.S. approach to the North Korean nuclear and missile threat, or even on the model of Gen. Barry McCaffrey's White House office leading U.S. anti-drug efforts. It is crucial that this be a full-time assignment, and not simply another in the myriad tasks facing the Vice President or the National Security Advisor; otherwise, other distractions will inevitably intervene. It is also crucial that such a coordinator have direct access to the President—both to give the coordinator the ability to rapidly raise key policy matters for immediate resolution when necessary, and to keep the President's attention on these issues—and the authority needed to get the job done.[1] Preventing nuclear material from falling into the hands of states like North Korea or Iraq is certainly no less critical to U.S. security than drugs or the North Korean nuclear program itself; indeed, the entire global effort to prevent the spread of nuclear weapons depends on it.

A Strategic Plan

The wide range of programs recommended in this report have many common purposes; the potential for synergy among them is enormous. Some programs require nuclear experts, to design and build systems to secure, monitor, and reduce nuclear stockpiles; other programs are seeking to provide jobs for nuclear experts. Some programs require facilities to process plutonium or uranium; other programs are seeking to convert plutonium and uranium processing facilities once used for the weapons program to new missions. Many are dealing with the same Russian nuclear institutions and facilities, often with the same individuals. Mistakes made by one program will color Russian attitudes and affect other programs, just as good will generated by one program

[1] For a detailed discussion of the organizational problems facing nonproliferation efforts in the U.S. government, see John Deutch (chair), *Report of the Commission to Assess the Organization of the Federal Government to Combat the Proliferation of Weapons of Mass Destruction*, Washington DC: July 14, 1999 (available at http://www.senate.gov/~specter/). The Commission recommended a senior coordinator similar to that recommended here, but covering all nonproliferation issues throughout the government; unless such a coordinator had a substantial staff, comparable to the White House drug office, such a broad coordinator might be swamped with too many critical issues to be effective. From its earliest days, the Clinton Administration established the office of Senior Director for Nonproliferation on the National Security Council staff, and the holders of that position have significantly improved nonproliferation coordination within the government—but they have too few resources for too many issues to be able to give the "loose nukes" problem the attention it requires. In late 1995, a new position of Director for Nuclear Materials Security was created on the NSC staff, reporting to the Senior Director for Nonproliferation and the Senior Director for Russian and Eurasian Affairs. This position was mandated in a Presidential Decision Directive to be focused exclusively on the issues addressed in this report, but in fact the holders of the office were very quickly swamped with other tasks, and in recent years have spent the majority of their time working on issues related to Russia's nuclear and missile cooperation with Iran.

may make it easier for another to get in the door. While each of these programs has its own unique circumstances, all of them face the common problems and obstacles endemic to nuclear security cooperation with Russia.

Unfortunately, today these programs are being pursued individually, with very little coordination among them, and virtually no systematic effort to pursue possible synergies. Officials at the U.S. embassy in Moscow report that it is not at all unusual to have several teams from U.S. laboratories arriving at the same Russian nuclear facility in the same week for completely different purposes, each unaware of the other's trip until they arrive.

Moreover, it is clear that not everything on this broad agenda can be done with equal energy at the same time, yet there has been very little effort to identify which efforts are the highest priorities. Both Russian and U.S. officials working on these programs are suffering from "initiative overload," and are unable to keep track of all the important efforts under way. While there is some virtue in letting a thousand flowers bloom (with the understanding that only a fraction will bear fruit), the need for a clear set of priorities is becoming increasingly obvious. A strategic plan setting such priorities and identifying possible synergies among these programs should be developed urgently, and should be coordinated closely with Russian officials.

There is much to be done to address the security risks posed by the deadly Cold War legacies of plutonium and highly enriched uranium. The cost of taking action now to address this threat is tiny by comparison to the cost and risk of failing to act and finding that the essential ingredients of nuclear weapons find their way into the hands of terrorists or proliferant states. The time for action is now. Indeed, we cannot afford to wait.

About the Author

Matthew Bunn is Assistant Director of the Science, Technology and Public Policy Program in the Belfer Center for Science and International Affairs at Harvard University's John F. Kennedy School of Government. His current research, carried out within the Managing the Atom Project, focuses on the management of nuclear warheads and nuclear material. From 1994-1996, Bunn served as an adviser to the White House Office of Science and Technology Policy, where he took part in a wide range of U.S.-Russian negotiations relating to security, monitoring, and disposition of weapons-usable nuclear materials. Previously, Bunn directed the study *Management and Disposition of Excess Weapons Plutonium*, by the U.S. National Academy of Sciences' Committee on International Security and Arms Control, published in two volumes in January 1994 and July 1995. The author of a book, several technical reports, and dozens of articles, he is a member of the Russian-American Nuclear Security Advisory Council, an organization devoted to promoting nuclear security cooperation between the United States and Russia, and the Board of Directors of the Arms Control Association.

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The Harvard Project on Managing the Atom (MTA) addresses two key problems underlying the management of nuclear technology: the intersections between nuclear energy and nuclear weapons, and democratic governance in nuclear decision-making. In addition to focused studies in these two areas, MTA collaborates with other groups to integrate these issues with others that bear on the future of nuclear energy and nuclear arms control. Current research priorities include:

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Joseph Cirincione, senior associate, directs the Project from Washington, DC, and Alexander Pikayev, a Carnegie Moscow Center Scholar-in-Residence, leads Moscow non-proliferation activities. Jon Wolfsthal is an associate with the Project, and Miriam Rajkumar serves as project associate.

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